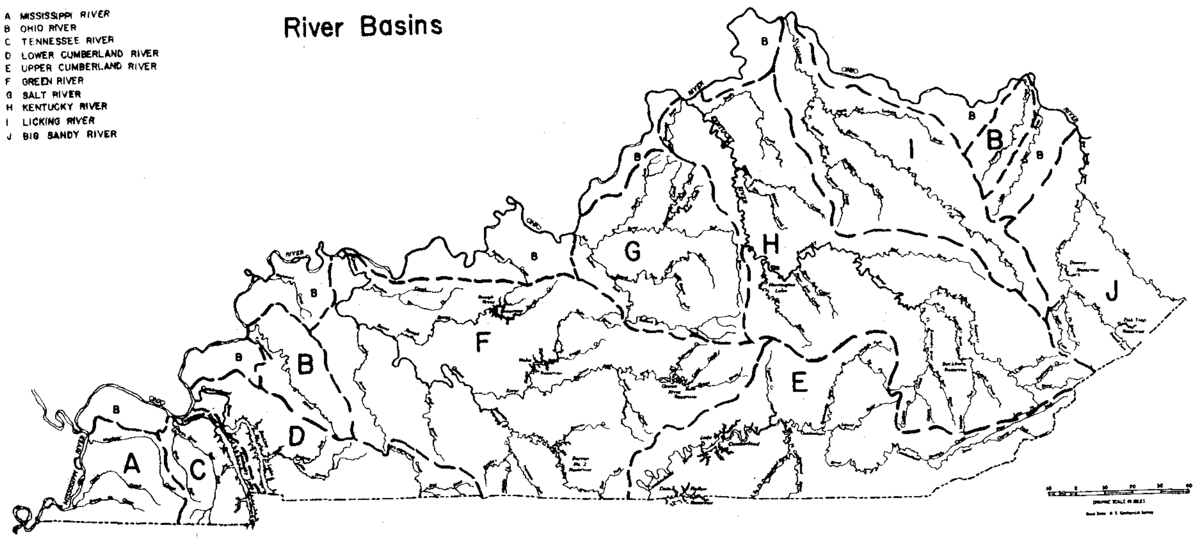
KENTUCKY WATER QUALITY REPORT TO CONGRESS



Department for Natural Resources and Environmental Protection
Division of Water (Quality)
Frankfort, Ky. 40601

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Contents

INTRODUCTION

This report is written to fulfill the requirement under PL 92-500, Section 305(b), to provide a report containing a description of the current water quality and the effects of water quality programs in Kentucky. The description is to include an indication of the extent to which the water quality has, can and will meet the goals of this act under these programs. To this end, the Kentucky Division of Water Quality has assembled information on past and current water quality. The future water quality in Kentucky can only be predicted in general terms in anticipation of policies and decisions of local, state and federal agencies.

The information which has been compiled and is presented is an update of the 1976 "Kentucky Water Quality Report to Congress." This report consists of a re-compilation of water quality data for periods prior to January 1, 1976 and data collected during calendar year 1976. The water quality data used was collected and reported to "STORET" by the United States Geological Survey. The data was retrieved from "STORET" and summarized in charts and tables. The Kentucky Division of Water Quality data on trace elements and bacteriological analyses was also used. Information concerning point source discharges was updated from the continuing planning efforts under Section 303e. The status of municipal construction grants was updated. A new section on major lakes was added. The U. S. Army Corps of Engineers provided a summary of the projects within the three Districts in Kentucky. The Ohio River Valley Sanitation Commission prepared an assessment of the "Ohio River Main Stem" which is available for calender year 1976.

SUMMARY OF WATER QUALITY IN KENTUCKY

The quality of water in Kentucky is the result of the interactions of rain waters contacting the earth, flowing over the land, soaking into and passing through the soil, over minerals, dissolving minerals into the waters and the waters transporting materials to the streams. The materials with which water contacts on its way to a stream or lake will dictate what these waters contain once they reach a stream or lake. In-organic materials (soil constituents, calcium, sulfate, chloride, etc.) will make up the bulk of the dissolved solids and will determine a water's hardness, acidity/alkalinity and other characteristics. Organic materials carried in the waters will effect to some degree the level of dissolved oxygen in the water through physical and biological processes in these waters.

As you read the different sections of this report, each written for a particular river basin, the characteristics of a river basin which have an effect on water quality will become evident. The size of a basin will determine how sensitive or insensitive to inflow and quality a river basin is. A small basin like the Salt River will react quickly to rains while a large impounded basin like Tennessee is relatively stable and slow to change.

The geology in a basin will effect the type of water produced. Within the Kentucky River Basin for example, Figure H-2 North Fork Kentucky River, (page 231) shows waters which have contacted disturbed earth in the Eastern Kentucky Coal Fields. This water is hard, high in dissolved solids, high in sulfate, high in acidity at times and high in chlorides. In contrast, the Red River, Pine Ridge in the same river basin (figure H-4, page 233) shows waters which have had few dissolved solids added, are relatively soft, have normal alkalinity and are of generally high quality.

The hydrology of each river basin has been presented. The term hydrology is used here to mean a summary of the important aspects of the amount of water which has been discharged past a measuring location on a stream. The following Table-1 will give the relative amount which eight of the ten river basins discharge during an average year.

Table I

AVERAGE DISCHARGE FROM RIVER IN KENTUCKY

OHIO RIVER	262,000 cfs*
TENNESSEE RIVER	64,000 cfs
CUMBERLAND RIVER	27,500 cfs
UPPER CUMBERLAND RIVER	9,100 cfs
GREEN RIVER	11,000 cfs
SALT RIVER	3,300 cfs**
KENTUCKY RIVER	7,200 cfs
LICKING RIVER	4,150 cfs
BIG SANDY	4,450 cfs

NOTE: These are the most downstream stations in each basin.

* Cubic feet per second.
** Sum of the two main streams, Rolling Fork and Salt River.

The population within a river basin will have an effect on streams due to the location and concentration of organic loads imposed on these streams. The population within each basin is shown in Table-2.

Table 2

POPULATION IN KENTUCKY

	BASIN	POPULATION 1970 Census	DRAINAGE AREA KENTUCKY	POPULATION DENSITY NO./ SQ.MI.
A.	Mississippi	56,637	1,250	45.3
B.	Ohio	993,001	6,090	163.1 [1]
C	Tennessee	68,412	1,000	68.4
D.	Lower Cumberland	92,380	1,900	48.6
E.	Upper Cumberland	260,000	5,077	51.0
F.	Green	426,000	8,821	48.3
G.	Salt	507,233	2,932	173
H.	Kentucky	534,000	7,033	105 [2]
I.	Licking	211,000	3,700	57.0
J.	Big Sandy	112,000	2,285	49.5
		3,261,072	40,088	81.3

Population greater than 50,000

1 *Louisville, Owensboro*

2 *Lexington*

The point source loads on streams which are predicted to depress the dissolved oxygen below 5.0 mg/l as a result of the population distribution within each basin is shown in Table-3. This table shows the effect of all treated effluents on streams in Kentucky in relation to the predicted dissolved oxygen content during design flows. It is shown by this table that the municipalities in Kentucky contribute 35 percent, the industries contribute 7 percent, and that small discharges contribute 58 percent of the organic point source loads which may cause the dissolved oxygen to be less than 5.0 mg/l in Kentucky streams.

Table 3

POINT SOURCE LOADS* IN KENTUCKY STREAMS

BASIN	STREAM MILES STUDIED	DISSOLVED OXYGEN PREDICTED LESS THAN 5.0 MG/L TOTAL MILES	MUNICIPAL	INDUSTRIAL	OTHER
A. Mississippi	275	84	13	26	45
B. Ohio	431	85	36	8	41
C. Tennessee	248	59	15	14	30
D. Lower Cumberland	360	62	40	0	22
E. Upper Cumberland	752	167	25	0	151
F. Green	1,670	214	173	6.8	34.5
G. Salt	596	160	61	8	91
H. Kentucky	868	145	119	0	26
I. Licking	1,000	384	89	46	249
J. Big Sandy	560	250	10	5	235
	6,760	1,609	570	114	925

* 1975 Wasteload Allocation from 303e River Basin plans.

There are 178 construction grants projects either active or pending in Kentucky for municipal wastewater facilities. Of these 178, 147 are Step 1's (201 planning), 20 are Step 2's (design), 11 are Step 3's (construction). During the last year seven (7) new or expanded plants, all funded under PL 84-660, were placed in operation. During this same period construction was started on only 1 new plant under PL 92-500. Table 4 is a summary of the grants status in Kentucky. Each river basin section contains a list of the municipalities receiving grants.

Table 4

SUMMARY OF GRANTS TO MUNICIPALITIES IN KENTUCKY

	BASIN	Step I	Step II	Step III
A.	Mississippi	8	0	0
B.	Ohio	25	3	3
C.	Tennessee	4	0	0
D.	Lower Cumberland	10	0	0
E.	Upper Cumberland	16	1	1
F.	Green	27	3	2
G.	Salt	9	5	2
H.	Kentucky	30	4	1
I.	Licking	11	4	2
J.	Big Sandy	7	0	0
		147	20	11

NOTE: These are pending and projects underway.

Table 5 shows the municipal dollar needs estimated in 1976 by category in order that cities in Kentucky may meet water quality criteria and growth expectations. The differences between the 1974 needs and the 1976 needs results from the revised criteria established by EPA for estimating.

Table 5

1976 NEEDS SURVEY

	1976 Needs Thousands Dollars
Category I Secondary Treatment	46,746
Category II Advanced Treatment	427,351
Category III A Inflow/Infiltration Correction	64,579
Category III B Major Sewer System Rehabilitation	0
Category IV A New Collectors	226,977
Category IV B New Interceptors	385,208
Category V Correction of Combined Sewer Overflows	132,184
Category VI Treatment and/or control of Stormwaters	152,933
Total Needs	1,435,978

The trace chemical water quality was compared to standards set by Kentucky in relation to health and public water supplies and to proposed Environmental Protection Agency standards. The waters which did not meet these standards are in areas of coal mining. The streams were Tradewater River, Olney (manganese greater than 50 μg/l) and the Upper Cumberland River at Harlan and Barbourville (iron greater than 300 μg/l)

The Division of Water instituted bacteriological monitoring at selected public water supply treatment facilities in FY74. The data from this program is presented in the water quality data tables. Since the period of record is only three years, no concrete conclusions have been drawn from the data at this time. A preliminary cursory look at this data indicates that the coliform bacteria (Total and Fecal) are high in relation to the state criteria. Of the 688 total coliform observations, 361 were greater than 1,000 colonies per 100 ml. for a 52% exceedance of the standard for drinking water. This represents an 11 percentage point increase over FY 75 observations.

When this recreational standard was exceeded or expected to be exceeded, a determination of fecal coliform was made (see Table 7). Table 7 shows that of 418 observations of fecal coliform, 211 were greater than 400 colonies per 100 ml. or 51 percent. The sixth annual report of the Council on Environmental Quality on page 361, Table 18 shows that 67 percent of the analyses for fecal coliform exceeded the recreation criterion. The fecal coliform observations for FY 76 indicate a 13 percentage point increase over the FY 75 observations.

A copy of Kentucky's current regulation 401 KAR 5:025 is included here for your reference in comparing specific quality conditions reported to the current standards. These standards also appear in each data section of the river basin reports for each parameter reported.

Department for Natural Resources
and Environmental Protection
Bureau of Environmental Quality
Division of Water Quality

401 KAR 5:025. Water quality standards.

RELATES TO: KRS Chapter 224
PURSUANT TO: KRS 13.082, 224.033(17)
SUPERSEDES: WP-4-1
NECESSITY AND FUNCTION: This regulation is to implement KRS 224.020. The regulation provides narrative water quality standards for all waters and sets forth a use classification scheme with numeric criteria for applicable waters.

Section 1. Prohibitions. No person or group of persons as defined in KRS Chapter 224 shall cause to be violated any one of the minimum standards in Section 2 or any one of the standards established in Sections 3 to 9 of this regulation.

Section 2. The following are minimum conditions applicable to all waters of the Commonwealth of Kentucky. All waters of the Commonwealth shall be:

(1) Substantially free from substances attributable to municipal, industrial or other discharges or agricultural practices that will settle to form putrescet sludge deposits;

(2) Free from floating debris, oil, scum and other floating materials attibutable to municipal, industrial or other discharges or agricultural practices in amounts sufficient to be unsightly or deleterious;

(3) Free from materials attributable to municipal, industrial, or other discharges or agricultural practices producing color, odor or other conditions in such degree as to create a nuisance; and

(4) Free from substances attributable to municipal, industrial or other discharges or agricultural practices in concentrations or combinations which are toxic or harmful to human, animal, plant or aquatic life.

(5) In the standards established by subsections (1) to (4), every person as defined in KRS Chapter 224 shall remove from their discharges those substances described in subsections (1) through (4) to the lowest practicable level attainable under current technology.

Section 3. Stream use classification. In addition to the minimum conditions set forth in Section 2, the use classification found in Sections 4 to 9 shall fovern where applicable.

Section 4. Public water supply and food processing industries. The following criteria are applicable to surface water at the point at which water is withdrawn for use for a public water supply or by a food processing industry:

(1) Bacteria: Coliform group shall not exceed 5,000 per 100 ml as a monthly arithmetical average value as determined by either MPN or MF count nor exceed this number in more than twenty percent of the samples examined during any month; nor exceed 20,000 per 100 ml in more than five percent of such samples.

(2) Threshold-odor number after normal treatment shall not be less than three.

(3) Dissolved solids shall not exceed 500 mg/l as a monthly average value, nor exceed 750 mg/l at any time. Values of specific conductance of 800 and 1.200 micromhos/cm, at 25 degrees Centigrade, may be considered equivalent to dissolved solids concentrations of 500 and 750 mg/l.

(4) Radioactive substances: Gross beta activity shall not exceed 1,000 picocuries per liter, pCi/l, nor shall activity from dissolved Strontium 90 exceed 10 pCi/l, nor shall activity from dissolved alpha emmitters exceed 3 pCi/l.

(5) Chemical constituents shall not exceed the following specified concentrations at any time:

Constituents	Concentrations, mg/l
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium (Hexavalent)	0.05
Cyanide	0.025
Fluoride	1.0
Lead	0.05
Selenium	0.01
Silver	0.05

Section 5. Industrial water supply. The following criteria are applicable to water at the point at which water is withdrawn for use, either with or without treatment, for industrial cooling and processing, other than food processing, and shall be applicable only within a mixing zone:

(1) pH shall not be less than 5.0 nor greater than 9.0 at any time.

(2) Temperature shall not exceed 95 degrees Fahrenheit at any time.

(3) Dissolved Solids shall not exceed 750 mg/l as a monthly average value, nor exceed 1,000 mg/l at any time. Values of specific conductance of 1,200 and 1,600 micromhos/cm, at 25 degrees Centigrade, may be considered equivalent to dissolved solids concentrations of 750 and 1,000 mg/l.

Section 6. Aquatic life. The following criteria are for evaluation of conditions for the maintenance of well balanced, indigenous fish population. The aquatic use standards shall not apply to areas immediately adjacent to outfall. Areas immediately adjacent to outfalls shall be as small as possible, be provided for mixing only, and shall not prevent the free passage of fish and drift organisms.

(1) Dissolved oxygen. Concentrations shall average at least 5.0 mg/l per calendar day and shall not be less than 4.0 mg/l at any time or any place outside the mixing zone.

(2) pH values shall not be less than 6.0 nor more than 9.0.

(3) Temperature shall not exceed 89 degrees Fahrenheit.

- (a) There shall be no abnormal temperature changes that may effect aquatic life unless caused by natural conditions.
- (b) The normal daily and seasonal temperature fluctuations that existed before the addition of heat due to other than natural causes shall be maintained.
- (c) The maximum temperature rise at any time or place above natural temperatures shall not exceed 5 degrees Fahrenheit in streams. In addition, the water temperature for all streams shall not exceed the maximum limits indicated in the following table:

Stream maximum temperature for each month in °F.

January	50
February	50
March	60
April	70
May	80
June	87
July	89
August	89
September	87
October	78
November	70
December	57

(d) The allowable temperature increase in public water impoundments shall be limited to 3 degrees Fahrenheit in the epilimnion if thermal stratification exists. Public water impoundments include all impounded water of the Commonwealth which are open to the public and used by the public.

(4) Toxic substances shall not exceed one-tenth of the 96-hour median tolerance limit of fish. Where there are substances that are toxic because of their cumulative characteristics, other limiting concentrations may be used in specific cases as presently approved by the Federal Environmental Protection Agency, or as later adopted by the Division of Water Quality.

Section 7. Put-and-take trout streams: The following criteria are applicable to those waters designated by the division as put-and-take trout streams:

(1) Dissolved oxygen concentrations shall not be less than 6.0 mg/l at any time or any place. Spawning areas, during the spawning season, shall be protected by a minumum DO concentration of 7.0 mg/l.

(2) Temperature: Stream temperatures shall not be increased artificially above the natural temperature at any time in cold water trout streams.

Section 8. Recreation: Unless caused by natural conditions, the following criterion shall apply in waters to be used for recreational purposes, including but not limited to such water-contact activities as swimming and water skiing. Bacteria: The total coliform level shall not exceed an average 1,000 per 100 ml. Total coliform shall not exceed this number in twenty percent of the samples in a month, nor exceed 2400/100 ml on any day. If the level of total coliform is exceeded, then a fecal coliform standard shall be used. There shall be a reduction of fecal coliform to such degree that during the months of May through October fecal coliform density in the discharge does not exceed 200 per 100 ml as a monthly geometric mean, based on not less than ten samples per month, nor exceed 400 per 100 ml in more than ten percent of the samples examined during a month, and not exceed 1,000 per 100 ml as a monthly geometric mean, based on not less than ten samples per month, nor exceed 2,000 per 100 ml in more than ten percent of the samples examined during a month.

Section 9. Agricultural: No criteria in addition to the minimum conditions enumerated in Section 2 are proposed for the evaluation of stream quality at the point at which water is withdrawn for agricultural and stock watering use.

Section 10. Multiple uses. One or more uses established in Sections 4 to 9 may apply to the same waters. The use criteria shall apply to those waters suitable for use or uses provided in Section 3. In the event there is a conflict between or among the applicable uses, the more stringent use criteria shall apply.

Table 6

TOTAL COLIFORM DATA FOR KENTUCKY

			Colonies/100 ml.			DATE	
Sta.	OBS	No. > 1,000	Mean	Min.	Max.	Beg.	End.
2	16	12	5607	0	19000	760114	760927
3	18	18	13980	1600	54000	760122	761214
6	15	11	5921	256	17600	760112	761122
7	18	13	3163	640	24600	760114	761202
8	4	3	2863	0	4900	760115	760401
10	5	4	2565	800	4600	760115	760422
14	19	19	24738	1090	110000	760121	761215
15	2	0	145	40	250	760720	761018
16	17	3	1946	0	18130	760112	761206
17	20	2	488	22	4800	760112	761206
18	19	9	1279	200	5000	760126	761215
19	20	18	12531	540	48000	760121	761215
20	17	2	903	48	6700	760129	761208
22	16	9	88493	33	688000	760111	761122
23	4	2	1000	393	1867	760122	761214
24	19	4	1364	60	10360	760112	761206
27	6	1	1091	640	2130	760121	761214
28	5	1	2239	200	10100	760115	760422
29	12	1	653	0	1950	760113	761208
33	20	19	17382	660	90000	760119	761214
36	5	5	64494	1200	259000	760309	761214
37	5	3	34581	220	159000	760121	761214
38	4	4	24180	2300	84000	760115	760401
39	3	2	4100	1000	7769	760115	760318
41	4	2	791	400	1250	760122	761214
42	5	3	42461	387	189000	760121	761214
43	11	3	1957	133	12000	760113	761208
45	11	11	3817	1050	7300	760210	761208
46	18	15	2438	650	10050	760113	761202
47	3	3	2555	1100	5300	760122	761214
49	14	14	8009	3100	19600	760113	761123
50	16	8	5832	188	28000	760112	761122
51	16	10	6714	64	26400	760112	761122
52	15	8	52716	42	215000	760113	761123
53	15	11	88175	169	860000	760113	761123
54	20	7	3247	24	17560	760112	761206
56	20	7	2262	60	8300	760112	761206
57	14	1	417	6	4120	760112	760809
58	20	8	2052	45	8560	760112	761206
59	20	5	1756	0	8251	760112	761206
60	20	5	2377	68	18320	760112	761206
61	17	1	243	10	1530	760114	761202
62	17	5	1240	151	6800	760129	761208
63	17	2	792	68	4800	760129	761208
64	17	3	900	97	7000	760129	761208
65	16	2	731	0	6359	760129	761208
66	2	2	8729	5833	11625	760122	760224
70	16	10	7445	300	82100	760114	761202
90	20	20	13069	2200	39000	760119	761214
96	19	19	123378	3100	1000000	760122	761214
155	16	11	5864	138	30000	760112	761122

52 percent of all observations were greater than 1,000 colonies/100 ml.

Table 7

FECAL COLIFORM DATA FOR KENTUCKY

Sta.	OBS	No. > 400	Colonies/100 ml. Mean	Min.	Max.	DATE Beg.	End.
2	16	6	321	0	1560	760114	760927
3	18	13	2460	100	18000	760122	761214
6	15	3	186	40	560	760114	761122
7	11	7	775	0	2000	760114	760908
8	8	4	1083	186	5500	760115	760930
10	6	5	4717	133	13830	760115	760831
14	18	15	2080	0	7600	760121	761215
16	2	1	240	0	480	760803	760809
17	2	0	70	0	140	760803	760809
18	15	5	397	0	2000	760126	761215
19	19	13	1430	80	6000	760121	761215
20	3	0	100	0	300	760325	761119
22	15	8	5658	25	37670	760114	761122
23	3	1	219	38	420	760122	760427
24	2	1	387	242	533	760803	760809
27	7	3	391	60	970	760624	761214
28	4	2	550	120	1380	760115	760831
29	6	2	290	0	1050	760113	760629
33	19	12	1617	85	11400	760119	761214
36	11	8	16910	100	96000	760121	761214
37	9	4	2965	130	16440	760121	761214
38	5	4	4365	233	18000	760115	760826
39	6	4	10240	187	53800	760115	760930
41	5	2	518	240	840	760122	761214
42	6	1	343	126	1200	760421	761123
45	10	7	2150	200	13730	760210	761208
46	13	7	1115	0	4067	760113	760811
47	6	3	4648	220	26000	760122	761214
49	13	4	396	99	1267	760119	761123
50	15	6	12279	26	135000	760114	761122
51	15	4	14743	25	205000	760114	761122
52	14	4	3770	15	24667	760119	761123
53	14	5	1197	44	4900	760119	761123
54	1	0	328	328	328	760803	760803
56	1	0	274	274	274	760803	760803
57	1	0	296	296	296	760803	760803
58	1	0	397	397	397	760803	760803
59	1	0	274	274	274	760803	760803
60	1	0	360	360	360	760803	760803
61	2	0	0	0	0	760323	760811
62	3	0	100	0	300	760325	761119
63	2	0	0	0	0	760325	760810
64	2	0	100	0	200	760325	761119
65	2	1	202	0	405	750205	760325
66	5	5	15992	480	71170	760122	760722
70	11	6	586	0	2000	760114	760811
90	20	15	1260	80	3200	760119	761214
96	19	14	5778	0	55000	760122	761214
155	15	6	1269	35	7110	760114	761122

51 percent of all observations were greater than 400 colonies/per 100 ml.

Water Quality Planning (Section 208)

An order resulting from a court suit (Natural Resources Defense Council, et. al. v. Train, et. al., D.C.D.C. Civ. Act. No. 74-1485) stipulated that water quality planning under Section 208 of Public Law 92-500 must be conducted by the states in all areas that are not designated in accordance with Section 208(a)(2) through (4). Under direction of the court, the Environmental Protection Agency promulgated revised 40 CFR Part 130-131 regulations. The regulations stipulated that the state agency designated by the Governor as the lead agency in water quality planning was responsible for Section 208 water quality planning in all nondesignated areas and for management and coordination of Section 208 planning in designated areas. The revised 40 CFR 130-131 regulations also listed sixteen elements which, as a minimum, were to be addressed in the initial 208 plan to be submitted to EPA by the states prior to November 1, 1978. These sixteen elements as listed in the regulations were:

(a) Planning Boundaries
(b) Water Quality Assessment and Segment Classification
(c) Inventories and Projections
(d) Nonpoint Source Assessment
(e) Water Quality Standards
(f) Total Maximum Daily Loads
(g) Point Source Load Allocations
(h) Municipal Waste Treatment System Needs
(i) Industrial Waste Treatment System Needs
(j) Nonpoint Source Control Needs
(k) Residual Waste Control Needs; Land Disposal Needs
(l) Urban and Industrial Stormwater System Needs
(m) Target Abatement Dates
(n) Regulatory Problems
(o) Management Agencies
(p) Environmental, Social, Economic Impact

Because the funding provided for accomplishing the required planning will not be made available in a manner so that all of the above elements can be completed in either the designated or the nondesignated areas by November 1, 1978 (as required by the court order), several of the above 16 elements will be deferred to the Continuing Planning Process and will be completed as funds and resources become available.

Nondesignated (Statewide) Areas

The Division of Water Quality in the Kentucky Department for Natural Resources and Environmental Protection is the state agency designated by the Governor to be the lead agency in planning under Section 208. Although the final work program for accomplishing the planning in nondesignated areas has not been completed and approved, the Division envisions making substantial effort in the following areas:

(1) Development and revisions of water quality standards (Surface and Groundwater),

(2) Beginning a process to control nonpoint sources of pollution from agricultural, forestry and construction activities,

(3) Revision of point source effluent limitations developed in the River Basin Plans published under Section 303 of Public Law 92-500,

(4) Studying the impact of surface mining on water quality in an area with existing high water quality and determining controls necessary to prevent water quality degradation in this high quality area,

(5) Development of a public participation process in water quality planning.

In the agriculture and forestry sectors, a voluntary nonpoint source control program through the application of conservation practices will be evaluated. If this program is not successful, mandatory implementation procedures will be evaluated. For construction a similar voluntary approach will be evaluated; however, the general indications are that mandatory controls are probably needed. Due to the almost iminent passage of Federal Surface Mining Controls a large program dealing with mining and water quality is not envisioned at this time. However, the effort to be undertaken should serve as a pilot study in this area. The principle mechanism for managing water quality from mining activity is expected to evolve through regulations promulgated under the Surface Mining Control and Reclamation Act of 1977. Another area considered for study in the initial 208 planning effort is residual wastes and water quality. However, the planning and regulations under the Resource Conservation and Recovery Act of 1976, should provide the major mechanism for inventorying the problem and managing water quality effects from residual wastes.

In addition to planning being undertaken by the Division of Water Quality to meet the requirements of regulations under Section 208, the Corps of Engineers has underway in the Lexington area an urban study which should provide information to fulfill many of the 208 requirements in that area.

The Lexington metropolitan area, in the Bluegrass region of Central Kentucky consists of Fayette, Bourbon, Clark, Jessamine, Scott and Woodford Counties. The basic objectives of the Corps of Engineers study related to wastewater management for the Lexington metropolitan area can be summarized as:

(1) Collection and evaluation of data for point sources at municipal and industrial discharges and estimation of wasteloads and their effect on water quality.

(2) Collection and evaluation of data on the land use and the non point sources and estimation of the non point pollution loads.

(3) Assessment of the problems due to point and non point sources and development of alternative management schemes and their relative costs.

(4) Overall assessment of Environmental, social and regional development impacts.

In the Lexington Urban Study area a considerable program is being conducted to identify the point sources of pollution, both municipal as well as industrial. An assessment of existing water quality in this area has been made in coordination with various concerned institutions. The major streams affected by the point source pollution include Town Branch, South Elkhorn Creek, North Elkhorn Creek, East and West Hickman Creek, Boone Creek and Cane Run. On the basis of available water quality data, Boone Creek can generally be described as good quality water. The North Elkhorn, South Elkhorn and West Hickman Creek are described as having fair water quality with problems in certain small segments. Town Branch is described as a very poor quality water stream.

Facilities planning under Section 201 of Public Law 92-500 is underway for most of the major municipal treatment plants in the Lexington area. This information will be incorporated into the Urban Study. The water quality of the streams degraded by the point sources is likely to improve significantly when facilities planning design and construction is completed. For the streams degraded in quality by both point and non point sources, the impact of non point sources will become more conspicuous, as point source controls are implemented.

Land use information has been compiled for the Lexington metro area with the use of remote sensing data using satelite imagery. A storm runoff study was undertaken in the Lexington area for the assessment of water quality problems due to urban runoff from several specific land uses. The results of this study indicated that relatively higher organic pollutant loadings resulted from the areas which included a large percentage of industrial and commercial land use. High dissolved solids resulted from commercial, industrial and a large combination of all land use types, primarily attributed to the winter time salt usage for de-icing. High suspended solids were experienced in all areas, with higher concentrations where de-icing was practiced with the aid of sand along with salt. High concentrations of metals were experienced from most storm sewers, with iron, lead and zinc being significant. Wet weather water quality data on Town Branch indicated high oil and grease in the stream.

Designated Areas

The State of Kentucky has two areas designated by the Governor for Areawide 208 Planning, one in the Cincinnati metropolitan area and one in the

Louisville Metropolitan area. Kentucky's portion of the Cincinnati 208 area includes all of Campbell, Kenton and Boone Counties in Northern Kentucky and deals with portions of both the Ohio and the Licking River Basins. The designated planning agency for this area is the Ohio-Kentucky-Indiana Regional Council of Governments (OKI). OKI was funded in June of 1974 but has received two six-month extensions, since they were one of the first areas to conduct planning under Section 208. The OKI initial 208 plan is due in June of this year and the Division of Water Quality is in the process of coordinating the preliminary review. The OKI 208 plan identifies a significant problem from sediment due to rural nonpoint sources in the Licking River. To alleviate this problem, they recommend establishing mandatory sediment control legislation. They also recommend that cost sharing money from different Federal and State agencies be combined and funding coordinated to eliminate duplicative funding and a priority system, based on water quality improvement, be developed to distribute these monies.

The Louisville 208 area includes all of Jefferson and Oldham and portions of Bullitt, Spencer, Shelby, and Henry Counties. This area includes portions of the Ohio and the Salt River Basins. The designated planning agency for this area is the Kentucky Indiana Planning and Development Agency, (KIPDA). This 208 area was funded in June of 1976, therefore only interim reports are available at this time. One of these interim reports contains data taken from some representative streams during rainfall events. This preliminary data indicates there is a problem with the bacteriological quality during storm events. After problem identification the next function of the 208 planning agency is to develop a management structure capable of managing the identified water quality problems. KIPDA is at this time evaluating various management alternatives through their public participation process.

Lakes Summary

This section represents that portion of the Water Quality St... in Kentucky which addresses lake water quality. It is intended as an extension of the Inventory of Lakes section in the Division of Water Quality 1974 Program Plan which is presented on the following page. The U.S. Army Corps of Engineers, as a participant in the coordinated water quality monitoring effort in Kentucky, has submitted water quality summaries for their fourteen major projects in the state. Table 1 presents a brief outline of the contents of these summaries. In addition, Table 2 presents a summary of water quality conditions at the fifteenth federal impoundment, Kentucky Lake, and a major private impoundment, Herrington Lake. The Kentucky Lake and Herrington Lake summaries were developed on the basis of limited water quality data obtained from the Tennessee Valley Authority and the Kentucky Department of Fish and Wildlife, respectively. On the basis of total area, the sixteen lakes summarized in this section represent 95 percent of the lake surface area in the state of Kentucky. Following the presentation of the Corps of Engineers lake reports is a glossary of general terms used within this section.

INVENTORY OF LAKES

	Federal USCE	S.C.S. State Municipal	Private
Total number of publicity owned fresh water lakes in the state	15	153	122
Total number of significant lakes			
Number of significant lakes exhibiting noticeable eutrophy			
Number of significant lakes exhibiting no noticeable eutrophy			
Number of significant lakes for which eutrophication status is not known E. G., data is not readily available to make a determination of its eutrophic status.			
Total area of publicly owned fresh water lakes	313,961	10,109	5,830
Total area of significant lakes			
Area of significant lakes exhibiting noticeable eutrophy			
Area of significant lakes exhibiting no noticeable eutrophy			
Area of significant lakes for which eutrophication status is not known.			

1. Federal-4 of 15 were a part of the National Eutrophication Survey none of the lake exhibited noticeable eutrophy.

2. Soil Conservation Service, State & Municipal — Most are used for public water supply, are small to moderate in size (20 to 850 acre) and the cities treat the lakes for algae control which precludes a judgment on the Eutrophic status.

3. Private (excludes Herrington Lake 2940 acres owned by Kentucky Utilities). Many lakes are for fee fishing, a few for water supply. Some lakes have public access and are developed with summer cottages. The fishing lakes would tend to a mesoeutrophic or eutrophic status because of artificial fertilization.

TABLE L-1a

WATER QUALITY SUMMARY OF THE MAJOR U. S. ARMY CORPS OF ENGINEERS PROJECTS IN KENTUCKY

PROJECT	CORPS DISTRICT	YEAR IMPOUNDED	THERMAL STRATIFICATION	DISSOLVED OXYGEN SUMMARY	MISCELLANEOUS PARAMETER SUMMARY
MARTINS FORK LAKE	NASHVILLE	Under Construction	Evaluation of water temperature data collected by U.S.G.S. will define the natural seasonal temperature regime.	Data base to be established after project completion.	Preimpoundment water quality data shows an increase in turbity levels and metals concentrations in Martins Fork.
LAUREL LAKE	NASHVILLE	1974	Typical of tributary type impoundment in the region.	Low hypolimnion dissolved oxygen, probably due to decay of organics in the recently impounded project. Trends in Hypolimnion dissolved oxygen to be monitored.	None Listed
LAKE CUMBERLAND	NASHVILLE	1950	Typical of tributary type impoundment in the region, however, all layers may not undergo complete mixing during winter.	Relatively low hypolimnion dissolved oxygen though not as severe as in similar projects.	Excessive turbidity in lower regions of lake.
DALE HOLLOW LAKE	NASHVILLE	1943	Typical of tributary type impoundment in the region.	Hypolimnion dissolved oxygen approaches zero near lake bottom in the fall.	None Listed
LAKE BARKLEY	NASHVILLE	1964	Does not stratify due to high current velocities in the upper reaches and low storage volume versus flow relationship.	Due to thermal stratification pattern, no significant dissolved oxygen problems exist, though isolated oxygen sags have been reported.	None Listed

Table L-1a
Continued

PROJECT	CORPS DISTRICT	YEAR IMPOUNDED	THERMAL STRATIFICATION	DISSOLVED OXYGEN SUMMARY	MISCELLANEOUS PARAMETER SUMMARY
CAVE RUN LAKE	LOUISVILLE	1973	Typical of tributary type impoundment in the region, having greatest impact on water quality in this lake.	Dissolved oxygen stratification develops with thermal stratification. Low hypolimnion dissolved oxygen near lake bottom.	Excessive dissolved iron and manganese concentrations produced in oxygen depleted hypolimnion. Low dissolved phosphorus concentration.
NOLIN RIVER LAKE	LOUISVILLE	1963	Typical of tributary type of impoundment in the region, having greatest impact on water quality in this lake.	Dissolved oxygen stratification develops with thermal stratification. Low hypolimnion dissolved oxygen near lake bottom.	Excessive dissolved iron and manganese concentrations produced in oxygen depleted hypolimnion. Moderated dissolved phosphorus concentration.
BARREN RIVER LAKE	LOUISVILLE	1964	Typical of tributary type of impoundment in the region.	Dissolved oxygen stratification develops with thermal stratification. Low hopolimnion dissolved oxygen near lake bottom.	Excessive dissolved iron and manganese concentrations produced in oxygen depleted hypolimnion. Low dissolved phosphorus concentration.
BUCKHORN LAKE	LOUISVILLE	1960	Typical of tributary type of impoundment in the region, having greatest impact on water quality in this lake.	Dissolved oxygen stratification develops with thermal stratification. Low hopolimnion dissolved oxygen near lake bottom.	Excessive dissolved iron and manganese concentrations produced in oxygen depleted hypolimnion. Low dissolved phosphorus concentration.
GREEN RIVER LAKE	LOUISVILLE	1969	Typical of tributary type impoundment in the region, having greatest impact on water quality in this lake.	Dissolved oxygen stratification develops with thermal stratification. Low hypolimnion dissolved oxygen near lake bottom.	Excessive dissolved iron and manganese concentrations produced in oxygen depleted hypolimnion. Low dissolved phosphorus concentration.

Table L-1a
Continued

PROJECT	CORPS DISTRICT	YEAR IMPOUNDED	THERMAL STRATIFICATION	DISSOLVED OXYGEN SUMMARY	MISCELLANEOUS PARAMETER SUMMARY
ROUGH RIVER LAKE	LOUISVILLE	1959	Typical of tributary type impoundment in the region, having greatest impact on water quality in this lake.	Dissolved oxygen stratification develops with thermal stratification. Low hypolimnion dissolved oxygen near lake bottom.	Excessive dissolved iron and manganese concentrations produced in oxygen depleted hypolimnion. Low dissolved phosphorus concentration.
CARR FORK LAKE	LOUISVILLE	1976	Typical of tributary type impoundment in this region, having greatest impact on water quality in this lake.	Dissolved oxygen stratification develops with thermal stratification, Low hypolimnion dissolved oxygen near lake bottom.	Excessive dissolved iron and manganese concentrations produced in oxygen depleted hypolimnion. Low dissolved phosphorus concentration.
DEWEY LAKE	HUNTINGTON	1950	Weak stratification during the summer.	Density layering effects cause the creation of secondary oxygen maxima in the dissolved oxygen distribution. Low hypolimnion dissolved oxygen at various levels.	Excessive levels of turbidity. High levels of iron and manganese correlating with high inflow levels. Occasional high mercury concentrations.
FISHTRAP LAKE	HUNTINGTON	1968	Weak stratification during the summer.	Density layering effects cause the creation of secondary oxygen maxima in the dissolved oxygen distribution. Low hypolimnion dissolved oxygen at various levels.	Excessive levels of turbidity. High levels of iron and manganese correlating with high inflow levels. Occasional high mercury levels in inflow and outflow.
GRAYSON LAKE	HUNTINGTON	1968	Typical of tributary type impoundment in the region.	Dissolved oxygen stratification develops with thermal stratification. Low hypolimnion dissolved oxygen near lake bottom. Outflow dissolved oxygen high due to high-level releases and stilling basin reaeration.	Excessive dissolved iron and manganese concentrations produced in oxygen depleted hypolimnion. Occasional high mercury levels. NOTE: Biological Survey Attached.

TABLE L-1b

WATER QUALITY SUMMARY OF THE MAJOR U. S. ARMY CORPS OF ENGINEERS PROJECTS IN KENTUCKY

PROJECT	WATERSHED ACTIVITY	IMPACT OF WATERSHED ACTIVITY	PROJECT STATUS AND PLANS
MARTINS FORK LAKE	Coal Mining Project related relocation work.	Possible water quality degradation due to mining activities or project relocation work.	Future efforts include expanded sampling, installation of automatic monitoring system, and preparation of project operation manual.
LAUREL LAKE	Project power generation in Fall of 1977. Future tailwater trout fishery.	Tailwater trout stocking program may have to be delayed until a means is found to alleviate poor quality releases from oxygen depleted	Future efforts include expanded sampling in coordination with the Kentucky Division of Water Quality and studies to find a means to alleviate the problem of poor water quality releases.
LAKE CUMBERLAND	Project power releases Tailwater trout fishery	Release of turbid water in lower regions of the lake causes water in the tailwater and downstream points to appear murky.	Future efforts include a complete evaluation of all available water quality data, a better definition of inflow quality, a definition of withdrawal zone produced by power releases, and a study of reaeration by turbulence in the tailrace.
DALE HOLLOW LAKE	Coal Mining Project power releases Tailwater trout fishery	Low dissolved oxygen hypolimnetic releases create concern for tailwater trout fishery. Water quality degredation due to mining activities in the watershed particularly in the East Fork, Obey River drainage.	Future efforts include a complete evaluation of all available water quality data, a better definition of inflow quality, a definition of the withdrawal zone produced by power releases, and a study of reaeration by turbulence in the tailrace.
LAKE BARKLEY	Project power releases	No significant adverse impacts with the exception of isolated oxygen sags.	Future efforts include a study of the monitoring deficiencies and adjustment of strategy for monitoring.

TABLE L-1b
Continued

PROJECT	WATERSHED ACTIVITY	IMPACT OF WATERSHED ACTIVITY	PROJECT STATUS AND PLANS
CAVE RUN LAKE	Strip Mining Oil & Gas Wells Salyersville & West Liberty Sewage Treatment Plants	Minor water quality degradation due due to strip mining. No discernable effect from oil and gas wells in upper reaches. Negligible effect from sewage treatment plants. Problems created at Morehead Water Treatment Plant, 1 mile below dam due to poor quality releases.	Influent water quality rated as generally good, but showing some effects of strip mining. Future efforts include a study of feasible structural modifications to outlet works to eliminate releasing hypolimnetic waters.
NOLIN RIVER LAKE	Agriculture Elizabethtown & Hodgenville Sewage Treatment Plants. Tailwater Trout Fishery.	Minimal effect from sewage treatment plants No nuisance algae blooms caused by relatively high nutrient levels produced by agricultural activity.	Influent water quality rated as relatively good.
BARREN RIVER LAKE	Oil Wells Glasgow Sewage Treatment Plant Tailwater trout fishery	No discernable effect from oil wells in upper reaches. Deleterious effects (low dissolved oxygen, algae blooms, odors, etc.) on Beaver Creek arm of lake caused by Glasgow Sewage Treatment Plant. Completion of new Glasgow Plant expected to improve water quality in Beaver Creek arm of lake.	Influent water quality rated as generally acceptable with the exception of Beaver Creek.
BUCKHORN LAKE	Strip Mining Hyden Sewage Treatment Plant Tailwater trout fishery	Minor water quality degradation due to strip mining. Negligible effect from Hyden sewage treatment plant in 1976.	Influent water quality rated as acceptable, but altered somewhat from natural conditions by strip mining.
GREEN RIVER LAKE	Liberty Sewage Treatment Plant Tailwater Trout Fishery	Negligible effect from Liberty Sewage Treatment Plant.	Influent water quality rated as excellent, having been only slightly altered from natural conditions.

TABLE L-1b
Continued

PROJECT	WATERSHED ACTIVITY	IMPACT OF WATERSHED ACTIVITY	PROJECT STATUS AND PLANS
ROUGH RIVER LAKE	Agriculture Tailwater Trout Fishery Leitchfield Municipal Water intake.	No nuisance algae blooms caused by nutrients produced by agricultural activity.	Influent water quality rated as relatively good.
CARR FORK LAKE	Strip Mining	Sediment loads (attributed to strip mining) offer greatest degrading potential for water quality. No significant overall effect due to acid mine drainage during 1976.	Influent water quality rated as generally good, but showing some effects of mining activities. Sediment retention structure completed February 1976 on Defeated Creek, with others to be constructed later if studies warrant.
DEWEY LAKE	Coal Mining	Degradation of water quality due to coal mining, resulting in excessive sedimentation and metals concentrations with possibility of adverse effects on the pH regime in the near future. Severe hydrogen sulfide odors in stilling basin produced in the oxygen depleted hypolimnion.	Lake water quality rated as poor to degraded. Future efforts include an ongoing sampling program oriented toward issues pertinent to existing or potential effects of sediment movement into and through the lake.
FISHTRAP LAKE	Coal Mining Tailwater Trout Fishery	Degradation of water quality due to coal mining, resulting in excessive sedimentation and metals concentrations with possibility of adverse effects on the pH regime in the near future.	Lake water quality rated as degraded to severely degraded. Future efforts include an ongoing sampling program oriented toward issues pertinent to existing or potential effects of sediment movement into and through the lake.
GRAYSON LAKE	Coal Mining Tailwater Trout Fishery	No significant adverse impact on water quality by mining activities at this time.	Lake water quality rated as fair to good. Future efforts include monitoring programs focused at both inflow and lake stations, and cooperative studies and regulatory effort with the State of Kentucky and other appropriate agencies.

TABLE L-2a

WATER QUALITY OF OTHER MAJOR LAKES IN KENTUCKY

IMPOUNDMENT	GOVERNING AGENCY	YEAR IMPOUNDED	THERMAL STRATIFICATION	DISSOLVED OXYGEN SUMMARY	MISCELLANEOUS PARAMETER SUMMARY
KENTUCKY LAKE	TENNESSEE VALLEY AUTHORITY	1944	Pattern similar to Barkley Lake. Some period of weak stratification.	Due to thermal stratification pattern, no significant dissloved oxygen problems exist	No excessive concentrations of trace elements with the exception of ocasional high levels of manganese.
HERRINGTON LAKE	KENTUCKY UTILITIES	1925	Typical of tributary type impoundment in the region.	Density layering effects cause the creation of secondary oxygen maxima in the dissolved oxygen distribution. Low hypolimnion dissolved oxygen at various levels.	Ranges of pH and alkalinity indicative of high buffering capacity of watershed. Occasional hydrogen sulfide odors occurring in low dissolved oxygen level of primary oxycline.

TABLE L-2b

WATER QUALITY OF OTHER MAJOR LAKES IN KENTUCKY

IMPOUNDMENT	WATERSHED ACTIVITY	IMPACT OF WATERSHED ACTIVITY	PROJECT STATUS AND PLANS
KENTUCKY LAKE	Project Power generation Phosphate mining on Duck River.	No significant adverse impacts on water quality by phosphate mining on Duck River or other activities in upper reaches.	Lake water quality rated as excellent. Future efforts include continued monitoring by Tennessee Valley Authority and related agencies.
HERRINGTON LAKE	Project Power Generation.	No significant adverse impacts on water quality at this time.	Future efforts include expanded monitoring in order to broaden the data base.

ACKNOWLEDGEMENTS

Data for this report was assembled from the following sources:

United States Geological Survey water quality data as retrieved through the "STORET" information system.

"Water Resources Data for Kentucky, Water Year 1975", U. S. Geological Survey Water-Data Report KY-75-1.

United States Army Corps of Engineers, Huntington District, Louisville District, and Nashville District

United States Department of Agriculture, Soil Conservation Service, Lexington, Kentucky.

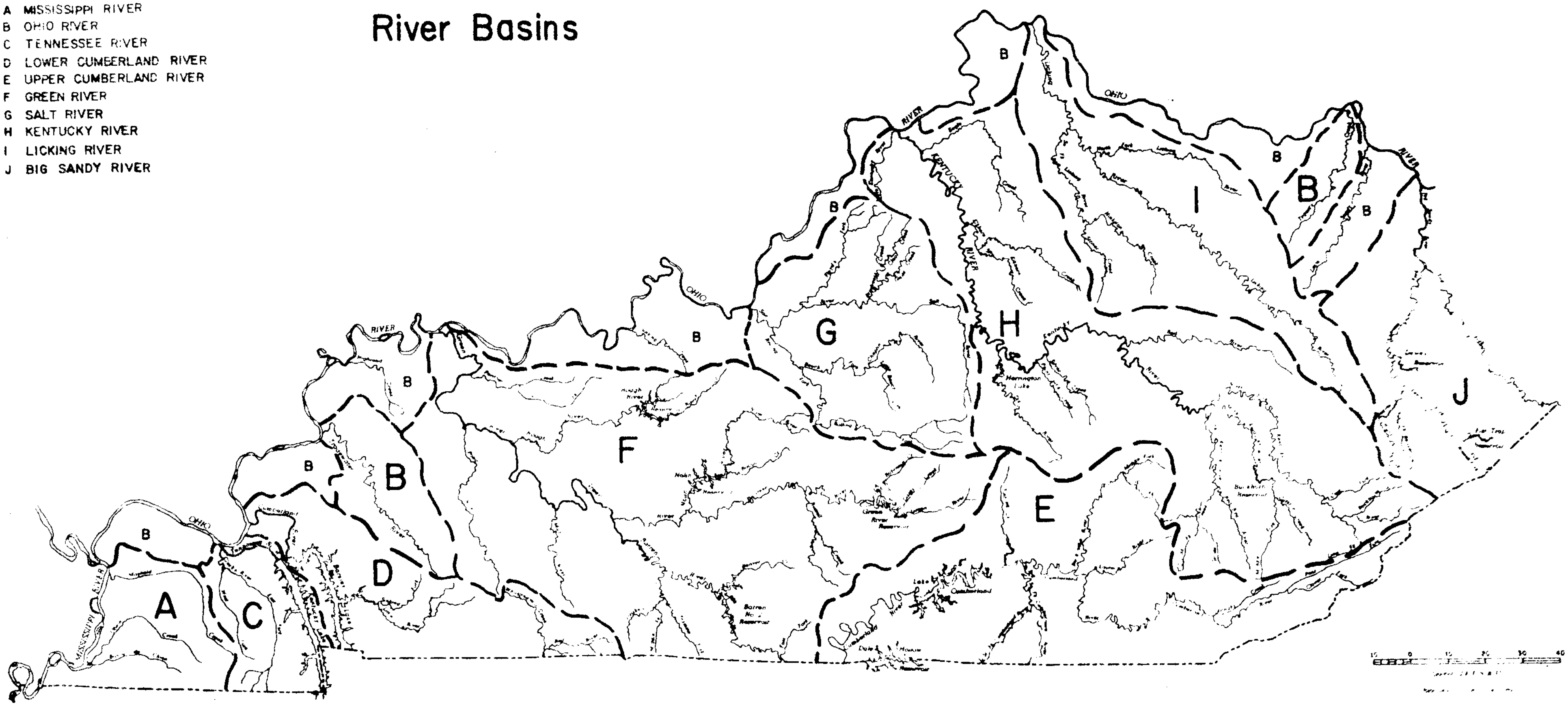
Kentucky Department of Fish & Wildlife Resources.

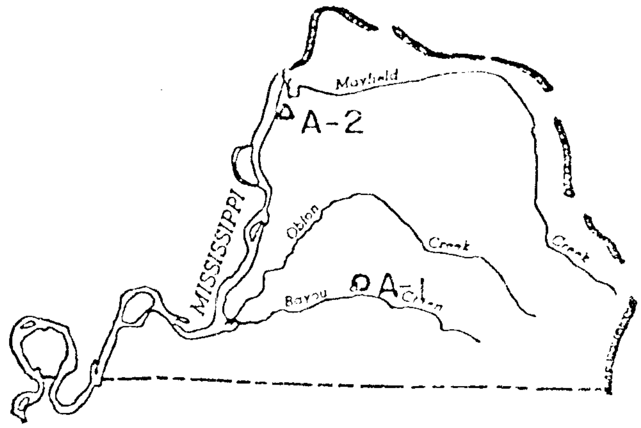
Kentucky Department for Natural Resources and Environmental Protection, Division of Water Quality

Ohio River Valley Sanitation Commission, Cincinnati, Ohio.

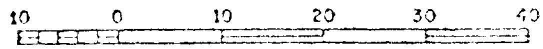
River Basins

A MISSISSIPPI RIVER
B OHIO RIVER
C TENNESSEE RIVER
D LOWER CUMBERLAND RIVER
E UPPER CUMBERLAND RIVER
F GREEN RIVER
G SALT RIVER
H KENTUCKY RIVER
I LICKING RIVER
J BIG SANDY RIVER





MISSISSIPPI RIVER



GRAPHIC SCALE IN MILES

Base Data: U. S. Geological Survey

THE MISSISSIPPI RIVER BASIN

The portion of the Mississippi River Basin in Kentucky makes up approximately one half of an area in the far western corner of the State called the Jackson Purchase region (named after General Andrew Jackson who, in 1818, arranged the purchase treaty with the Chickasaw Indians). The Jackson Purchase region is unique in many respects from the rest of Kentucky. This report will discuss first the Mississippi River Basin in general in the region, and secondly discuss existing water quality in the area and the factors that influence water quality in the basin.

I. Basin Description

A. Geography

The Mississippi River forms the western boundary of the Commonwealth of Kentucky from the confluence of the Ohio River at Cairo, Illinois to the Tennessee border. The Mississippi enters Tennessee and in reversing direction, a small area of Kentucky is thus formed and known as the New Madrid Bend.

This basin contains all or portions of the following counties: Ballard, Carlisle, Hickman, Fulton, Graves, McCracken and Calloway and encompasses a total drainage area in Kentucky of approximately 1,250 square miles (Table A-1). Several streams are tributary to the Mississippi River, with their respective areas in Kentucky shown in square miles in parentheses following the names of the tributaries. They are: Mayfield Creek (438.0), Obion Creek (319.0), Bayou du Chien (214.0), and Obion River (146.0). An additional 138.0 square miles are directly tributary to the Mississippi River.

B. Topography

The topography of the basin is such that the headwater areas in the watersheds are hilly, resulting in severe sand and soil erosion problems. However as the land approaches the Mississippi River it becomes gently rolling, ending abruptly in a flat flood plain. Elevations vary from 267 to 560 feet above sea level, with average major tributary slopes ranging from approximately 4.0 to 7.0 ft./mi. The main stem of the Mississippi has an average slope in this area of 0.33 ft./mi.

C. Geology

The geology in this area represents four major formation types, made up of sand, clay, gravel, and silt in varying amounts. These are situated on a bedrock composed of limestone, chert, and dolomite. Surface waters are given a bicarbonate hardness by this limestone bedrock. Groundwater from this area is generally quite good, although some problems occur depending upon the formation from which it is drawn. Water hardness, pH, and high iron content are the major groundwater problems. The high iron content is encountered most frequently when water is drawn from the bedrock of the area. However, due to the constancy of water quality, temperature, and yield (as high as 1,700 gallons per minute) groundwater remains the major source of domestic and industrial water supply in the Mississippi region.

D. Hydrology

The Mississippi River itself is, of course, one of the most important rivers in the world as it relates to commercial barge traffic. It is under the jurisdiction of the U. S. Corps of Engineers for the maintenance of navigation and flood control. A series of locks and dams and upland storage upstream of St. Louis, along with channel maintenance assure a channel depth of 12 feet from the mouth to the confluence of the Ohio River by maintaining pools and augmenting low flows.

Tributaries to the Misssissippi River in Kentucky (excluding the Ohio River), although equipped with flood retarding structures, are not flow regulated or is the flow augmented by dams and reservoirs. Surface water flows, recorded at gauging stations situated along each major tributary give a picture of the hydrology in the region. The flows are listed in Table A-6 on the following page.

The natural low flow in each of these three tributaries is above the average for comparable sized drainage basins in Kentucky. Bayou de Chien has the highest natural low flow in this area of the Mississippi Basin, due to the groundwater contribution to the surface water flow. The groundwater contribution improves water quality in the area due to the greater quality of water available for dilution wasteloads.

E. Population

The total population (1970) in the Mississippi River Basin in Kentucky numbers 56,637. Mayfield, Kentucky in Graves County, with a population of 10,600 has the largest population in the basin. Ten smaller communities make up the rest of the urban population of 21,380 which represents 38 percent of the total population. Columbus, Kentucky, a community of 371 people, is the only incorporated, unsewered community in the basin. The remainder of the population is located in rural area. The urban distribution is shown in Table A-3. Population in a basin is an important factor in the water quality of the basin, as water is used for a great variety of purposes, then discharged back into the streams.

TABLE A-6

SURFACE WATER RECORDS FOR THE MISSISSIPPI RIVER BASIN

STATION	PERIOD OF RECORD	DRAINAGE AREA	AVERAGE FLOW	MAXIMUM FLOW	MINIMUM FLOW	7-day/10-yr. LOW FLOW
Mayfield Creek at Lovelaceville	wtr/yr 1976**	212 sq.mi.		11,000 cfs, 52 cfs*/sq.mi.		7.9 cfs
Obion Creek at Pryorsburg	wtr/yr 1976***	36.8 sq.mi.		5,880 cfs, 160 cfs/sq.mi.		
Bayou de Chien near Clinton	37 yr.	68.7 sq.mi.	102 cfs, 1.5 cfs/sq.mi.	9,460 cfs, 138 cfs/sq.mi.	4.0 cfs, 0.1 cfs/sq.mi.	6.3 cfs
	wtr/yr 1976		268 cfs, 3.9 cfs/sq.mi.	5,160 cfs, 75 cfs/sq.mi.	8.8 cfs, 0.1 cfs/sq.mi.	

* Cubic feet per second

** Operated as a continuous-record gaging station 1938-72. and as a crest-stage partial-record station since 1973

*** Operated as a continuous-record gaging station 1952-65, and as a crest-stage partial-record station since 1974.

NOTE: Data is taken from "Surface Water Records in Kentucky" by the United States Geological Survey. The 7-day/10-yr. low flow was taken from the waste load allocation produced as a component of the 303e River Basin Continuing Planning Process.

II. Basin Water Quality

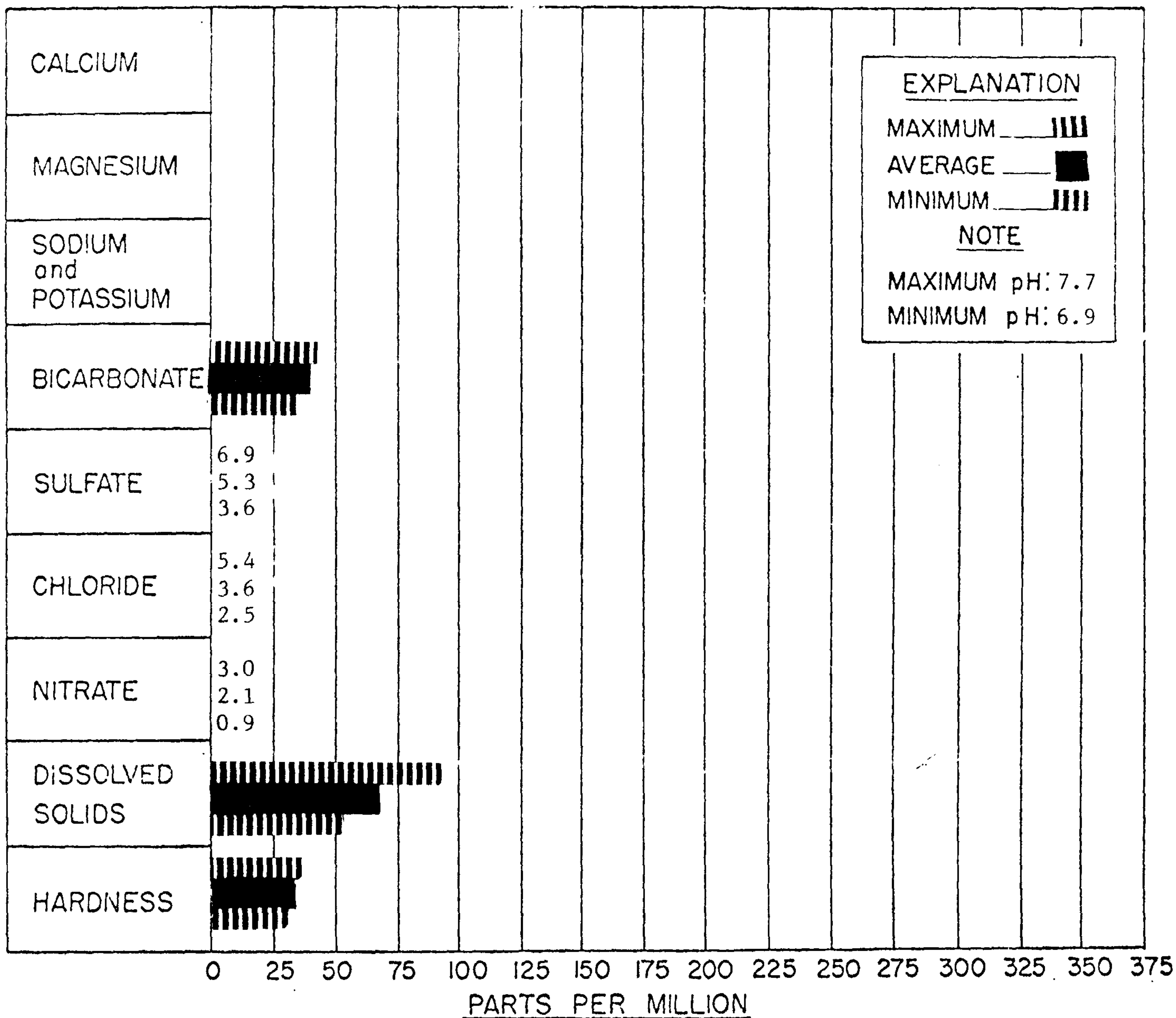
A. Description of Sampling Stations

Samples of the water, for testing its quality, were taken at a U.S.G.S. flow gaging station on Mayfield Creek at Lovelaceville, Kentucky. This is located in Carlisle County, in the north central portion of the basin. Drainage area above the station is 212 sq. mi. representing 17 per cent of the total drainage area in the basin. Data obtained from this sampling point is shown in Table A-4 and presented graphically in Figure A-1.

B. General Chemical Water Quality

The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The chemical characteristics of a stream when viewed over a long period of time is primarily from surface water. The type of rock formation and soils which the surface water contacts causes this predominate chemical characteristic. The contribution of groundwater, which is generally higher in dissolved solids than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky is one of moderate hardness caused by calcium and magnesium salts.

Thence the portion of the Mississippi River Basin in Kentucky, is very soft with a slight bicarbonate hardness. The following information was taken from "Water in the Economy of the Jackson Purchase Region", a Kentucky Geological Survey report. This basin is relatively undisturbed by man's activities which would cause a modification of the General Chemical Water Quality. The water of the region is therefore practically free from the influence of human

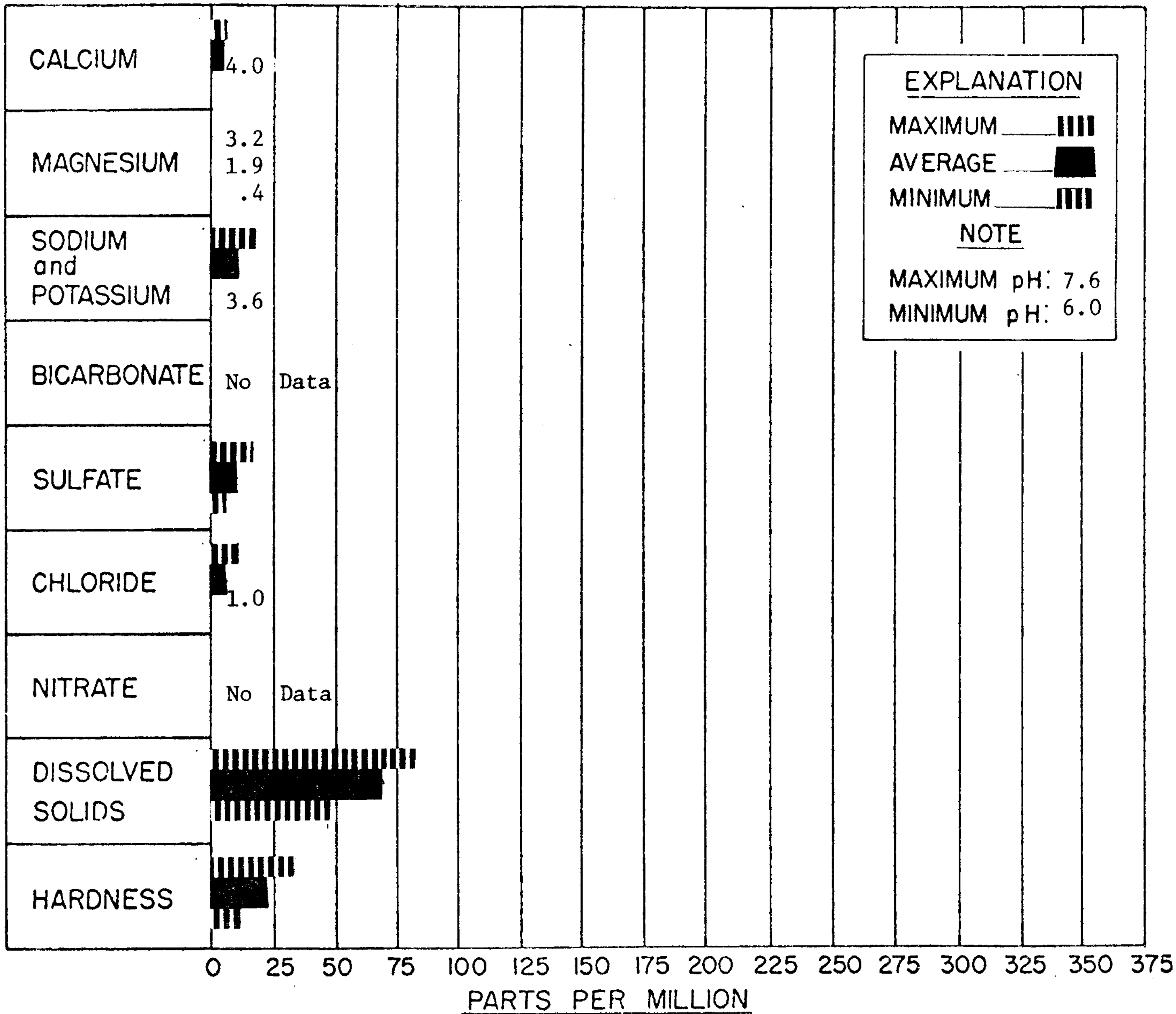


MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE A-1

Bayou de Chien

North Clinton



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE A-2

Mayfield Creek

Lovelaceville

10-60 to 8-72

related pollutants. For this reason, in all respects the quality of the surface water falls well within normal standards (excepting D.O. at extreme low flow periods) and is considered to be excellent as it is shown on Figure A-1.

C. Trace Chemical Water Quality

Trace elements under 5.0 mg/l are separated from the general chemical background of this report because of their influence on human health. Generally, these materials are "heavy" metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State-Federal Water Quality Standards.

Trace chemicals in the surface water of the Mississippi River Basin in Kentucky were measured as being within Kentucky-Federal Water Quality Standards.

D. Waste Load Effects on Water Quality

Biochemically degradable wastes impose a load on the dissolved oxygen recourses of a stream. Such waste loads are considered to have an effect upon water quality when they cause the dissolved oxygen (D.O.) concentration to drop below the Kentucky Water Quality Standard of 5.0 mg/l. Based on a model developed for the Kentucky Continuing Planning Process for River Basin Management Planning, 275.0 miles of streams in the basin that receive waste discharges were evaluated. Based upon present treatment levels and once in 10 year 7 day low flows, there are 84.0 miles of stream where the D.O. concentration may be expected to fall below 5.0 mg/l. Thirteen of the 84 miles of stream are affected by a municipal discharge, 26 by industrial, and 45 by various other discharges. These distances represent 5 per cent, 11 per cent, and 15 per cent, respectively, of the total stream miles in the basin which were studied. (Table A-5)

E. Non-Point Source Effects

Non-point pollution is a problem in Kentucky's portion of the Mississippi River Basin. The major non-point sources of pollution in the basin are summarized below:

1. Land Use: Soil erosion from 273 square miles (22 per cent of basin area) of farm land is considered excessive. Logging operations, burning, and grazing in 56 square miles (.05 per cent of basin area) of forest land has resulted in severe soil erosion in the area.

2. Animal Wastes: All agricultural feedlots in Kentucky have a capacity of less than 1,000 animal units and, therefore, no NPDES Permits have been issued in Kentucky for feedlots. Kentucky has developed a manure lagoon disposal system in cooperation with the USDA-SCS which is currently under study and is used by some feedlots. These lagoon systems have been employed in the Mississippi River Basin and have minimized the waste load effect from feedlots when properly operated.

3. Urban Runoff: Mayfield, Kentucky is the only city which could influence water quality from urban runoff. The effect of urban runoff should be partially mitigated through a unique sanitary sewer overflow lagoon which acts as a detention and treatment basin before discharging to the main sewage treatment plant for further treatment. The overflow lagoon was a cost effective solution to a severe inflow/infiltration problem rather than eliminating stormwater access to the sanitary sewer system.

F. Water Uses

Surface and groundwaters in the Mississippi River Basin in Kentucky are used for public water supply, industry, fish and wildlife, recreation, and for agriculture. The groundwater of Kentucky's portion of the Mississippi River Basin is of good quality, however, iron removal is needed. The groundwater yield is high (500 g.p.m. and up to 1,700 g.p.m.) and is the source of all of the public water supply in the region. Public water usage is 2.0 million gallons per day (m.g.d.)

Industry, too, relies heavily upon the consistently high quality groundwater as its water source. Except for a large paper mill located directly on the Mississippi River (Westvaco) all of the industry in the basin uses 4 m.g.d. of groundwater for water supply.

There are no major organized recreational areas situated in the basin. However, the quality of the streams in the region is sufficiently high enough to support fish and wildlife, and to allow its recreational use.

Water in the basin is used in the agricultural industry primarily for livestock watering with a small amount used for irrigation.

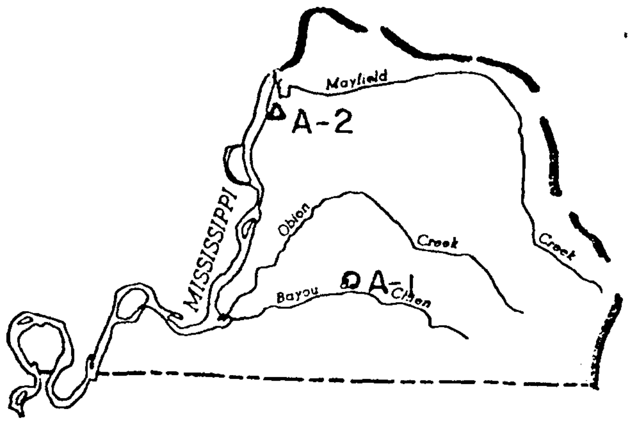
G. Water Quality Changes

The water quality through the basin is excellent and, therefore, sampling is limited and any change in water quality in the Mississippi River Basin in Kentucky must be observed over long periods to be meaningful.

III. Summary

The water quality in Kentucky's Mississippi River Basin is of high quality. There are some problems related to water quality that require attention. Soil erosion from both farm land and forest land presents a problem of sediment in the water.

Treated wastes discharged from municipal, independent, and industrial sources effect the quality of the basin's streams. The need to upgrade or eliminate waste sources is being determined in the basin planning process. Another aspect of this problem is the need for improved operation and maintenance of waste treatment facilities through a program of operator licensing and education. Kentucky has instituted such programs.



○ U.S.G.S.

△ Kentucky Division of Water

MISSISSIPPI RIVER

10 0 10 20 30 40

GRAPHIC SCALE IN MILES

Base Data: U. S. Geological Survey

STATION KEY

A-1 BAYOU DE CHIEN NEAR CLINTON

A-2 MISSISSIPPI RIVER NEAR WICKLIFFE WPI

Table A-1
Population in the Mississippi River Basin by County

County	Area (sq. mi.)	1970 Pop.	Area in Basin (sq. mi.)	Pop. in Basin
Ballard	259	8,276	113	5,306
Calloway	384	27,692	17	610
Carlisle	195	5,354	195	5,354
Fulton	203	10,183	203	10,183
Graves	560	30,939	458	27,445
Hickman	246	6,264	246	6,264
McCracken	249	58,281	17	1,475
			1,249	56,637

Note: The information in this table was taken from the 1970 Census as reported in Rand McNally.

Table A-2

Water Withdrawal in the Mississippi River Basin

County-City-Withdrawer	River/Stream	SW	GW	Public (mgd)	Industrial (mgd)
Ballard					
Barlow Mncp. W. W.			x	.036	
LaCenter Mncp. W. W.			x	.1	
Wickliffe Mncp. W. W.			x	.08	
Westvaco	Miss. R.	x			25.0
Calloway	No Major Withdrawal				
Carlisle					
Arlington Mncp. W. W.			x	.02	
Deena of Arlington, Inc.			x	.001	.056
Bardwell City Utilities			x	.11	.012
Fulton					
Hickman Mncp. W. W.			x	.7	
Graves					
Cuba Mncp. W. W.			x	.006	
Fancy Farm Water Dist.			x	.041	
Hickory Water Dist.			x	.075	
Lynch Water Dist.			x	.003	
Lowes - Mrs. John Lowe			x	.005	
Lynnville - Motheral Water Co.			x	.007	
Mayfield Mncp. W. W.			x	.66	.49
Beadleton Comm. W. System			x	.005	
Hardeman Water Dist.			x	.018	
Dairy Brand of Mayfield, Ky.			x		.012
General Tire and Rubber Co.			x		3.2
Pet Milk Co.			x		.25
Sedalia Water Dist.			x	.014	
Tri-City - Mrs. Myrtle Casey			x	.004	
Water Valley Mncp. W. W.			x	.075	
Wingo Mncp. W. W.			x	.092	.005
Hickman					
Clinton-Ky. W. Service Co.			x	.11	.013
Columbus Mncp. W. W.			x	.011	
McCracken	No Major Withdrawal				

*Mncp. W. W. - Municipal Water Works

NOTE: Data obtained from Kentucky Department for Natural Resources and Environmental Protection, Division of Water Resources.

Table A-3

City Population and Facility Grant Status
in the Mississippi River Basin in Kentucky

County	City	Population	Project Type	Comments
Ballard	Wickliffe	1,211	1	Active
	LaCenter-	1,044	1	Active
	(Barlow)			
	(Kevil)			
Calloway				
Carlisle	Bardwell-	1,049	1	Active
	(Arlington)	549		
Fulton	Fulton	3,250	1	Active
	Hickman	3,049	1	Active
Graves	Mayfield	10,600	1	Active
	Wingo	593	1	Active
	Fancy Farm	550	1	Active
Hickman	Clinton	1,618	None	Sewers/STP
	Columbus	371	None	No Sewers
McCracken				

NOTE: Project type is related to the grant process step applied for or active for each municipality. Step 1 is the preliminary studies (201 Facilities Plan) required before design of the facilities. Step 2 is the design phase of the project, and Step 3 is the construction of facilities for the collection and treatment of wastewaters.

The comments relate to the status of the grant. <u>Active</u> indicates the project is funded and underway. <u>Pending</u> indicates that application for a grant has been made and is pending approval. <u>No sewers</u> indicates that the municipality does not presently have a comprehensive sewer system. <u>Sewers/STP</u> indicates the municipality is now served by sewers and treatment facilities.

The source of this information was the 1970 U. S. Census and the FY 77 construction grants list for Kentucky.

Table A-4

Water Quality Data for the Mississippi River Basin

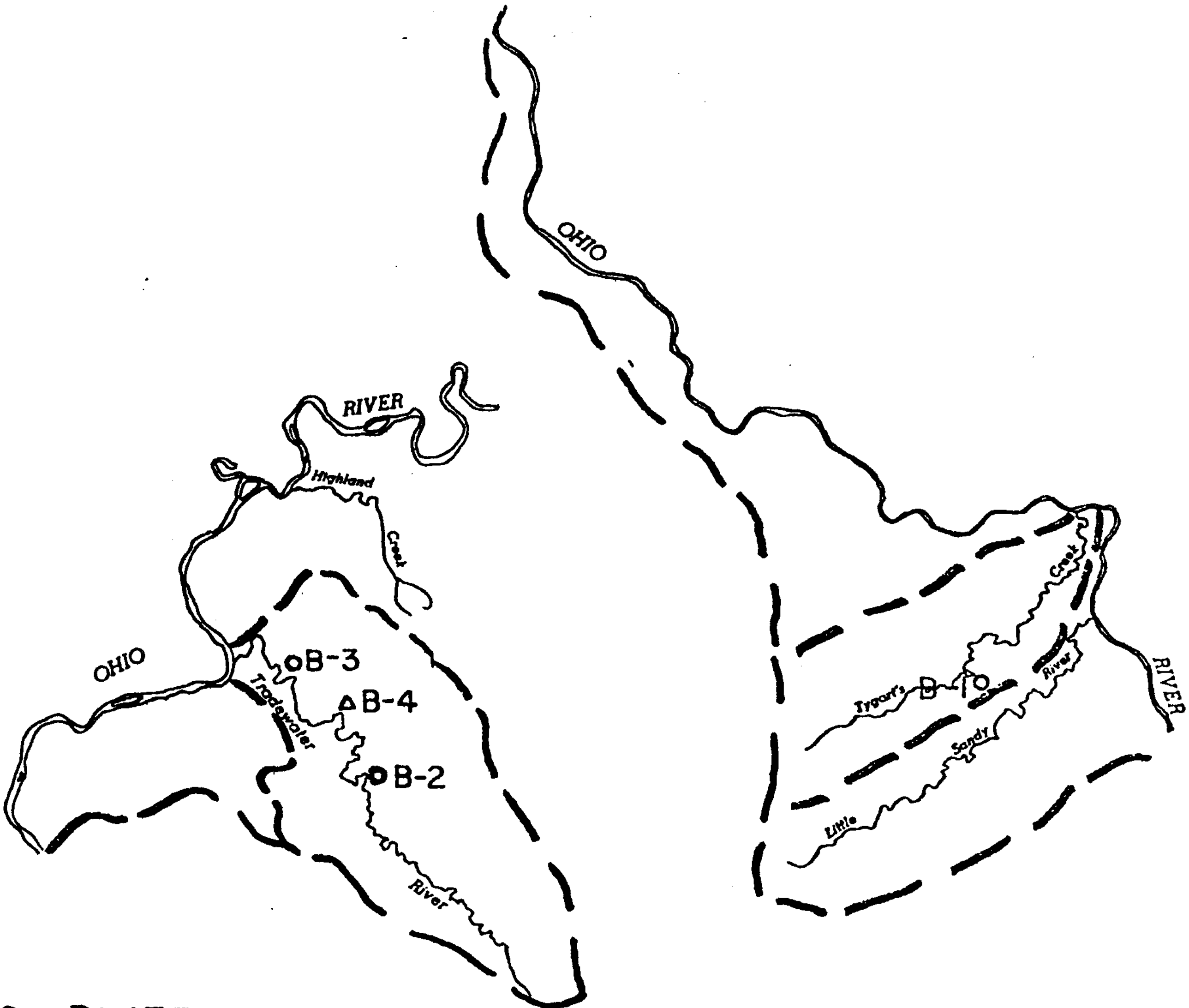
Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
STORET #00400	pH Specific Units Kentucky Standard 6-LT pH LT 9						
Bayou De Chien, Clinton USGS #07024000	70/11/04	72/08/17	7.2	7.7	6.9	3	0.436
STORET #00095	Conductivity Micro mho, Ky. Std. 800 micro mhos						
Bayou De Chien, Clinton	70/11/04	72/08/17	105	122	95	3	14.6
STORET #70300	Residue mg/l (milligrams per liter), Ky. Std. 500 mg/l						
Bayou De Chien, Clinton	70/11/04	72/08/17	68	88	52	3	18.4
STORET #00900	Hardness mg/l, 0-60 Soft, 61-120 MOD, Hard, 121-180 Hard, 180 + Very Hard						
Bayou De Chien, Clinton	70/11/04	72/08/17	37	39	34	3	2.65
STORET #00940	Chloride mg/l, Proposed E.P.A. Std. 250 mg/l						
Bayou De Chien, Clinton	70/11/04	72/08/17	3.6	5.4	2.5	3	1.55
STORET #00945	Sulfate mg/l, Proposed E.P.A. Std. 250 mg/l						
Bayou De Chien, Clinton	70/11/04	72/08/17	5.3	6.9	3.6	3	1.65
STORET #00950	Fluoride mg/l, Ky. Std. 1.0 mg/l						
Bayou De Chien, Clinton	70/11/04	72/08/17	0.07	0.1	0.0	3	.0577
STORET #00410	Alkalinity mg/l, No Standard						
Bayou De Chien, Clinton	70/11/04	72/08/17	42	43	41	3	1.0
STORET #71851	Nitrate mg/l, Prop. E.P.A. Std. 10 mg/l						
Bayou De Chien, Clinton	70/11/04	72/08/17	2.1	3.0	0.9	3	1.07
STORET #31503	Total Coliform Count Per 100 ml., Ky. Std. 1000 per 100 ml.						
Mississippi R.,	75/01/07	75/12/16	1254	4700	25	11	
Wickliffe WPI	74/04/16	75/12/16	1435	4700	25	21	
STORET #31616	Fecal Coliform Count Per 100 ml.						
Mississippi R., Wickliffe WPI	75/07/22	75/11/25	409	587	250	3	

Table A-5

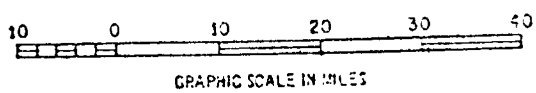
Organic Loads Affecting Streams in the Mississippi River Basin

Length of streams to which treated organic loads are discharged		275.0
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow		84.0
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow due to	Municipal Discharges	13.0
	Industrial Discharges	26
	Other Discharges	45

Note: This information is from the wasteload allocation for Kentucky and is an output from the 303e river basin planning effort. The values indicate the stream miles in which the dissolved oxygen is predicted to be less than 5 mg/l when the stream flow is less than the once in ten year seven day (Q10-7) low flow.



OHIO RIVER



Base Data: U. S. Geological Survey

OHIO RIVER BASIN - MINOR TRIBUTARIES

The minor tributaries to the Ohio River which are to be considered are the Tradewater River, the Little Sandy River and Tygarts Creek along with other small drainage basins which have drainage directly to the Ohio River rather than major tributaries. The main stem of the Ohio River of the Water Quality Report has been prepared for the 8 signator states composing the Ohio River Valley Sanitation Commission and this separate report is available on request from ORSANCO, 414 Walnut Street, Cincinnati, Ohio.

I. Basin Description

A. Geography

Since the border of the Ohio River forms the north border of the Commonwealth of Kentucky and is 610 miles in extent; the geography will be discussed in three separate sections. (1) The area from Ashland to Northern Kentucky, (2) the area from Northern Kentucky to Louisville, and (3) Louisville to the mouth of the Ohio.

In the first area (1) there are three tributaries in the sub-basin; two of which, the Little Sandy and Tygarts Creek, compose about two thirds of the drainage basin area from Ashland to Northern Kentucky. This portion of the drainage basin is relatively uninhabited with the exception of three towns over 1,000 population. It is very hilly and activity from crop farming is restricted by the topography.

The second area (2) running from Northern Kentucky to Louisville has one drainage basin with an area of over 100 square miles that is Harrods Creek. The geography of the area is very similar to the first area.

The third area (3) from Louisville to the mouth contains one large drainage basin, the Tradewater River. The Tradewater River has a drainage area of 940 square miles. Two other tributaries - Highland Creek and Sinking Creek - have drainage areas of over 100 square miles. Generally, this area has some farm and mining activities; the intense mining activities are in the Tradewater River Basin.

B. Topography

The particular topographic feature which relates to water quality is the slope of the streams. The slope of a stream directly relates to the ability or capacity of the stream for waste load assimilation. The slope relates to the reaeration capability and if the stream has no flow, a direct relationship of the slope to the waste load exists permitting a simple estimate of load which can be discharged into that stream. In area one (1), the slopes of the streams are: Little Sandy River, 8.3 feet per mile and Tygarts Creek, 6.9 feet per mile. In area two (2), the stream slopes are somewhat flatter, varying from three to four feet per mile. In area three (3), the Tradewater River has an average slope of 1.3 feet per mile from the headwater to mile point 70 from the Ohio River. The lower portion from mile point 60 to the mouth is subject to backwater influences of the Ohio River. The lower 70 miles has a slope of 0.7 feet per mile. In area three (3), the slope is generally less than 3 feet per mile for the minor tributaries.

C. Geology

An important geological feature of the Ohio River minor tributaries is a glacial alluvial deposit that extends from a half mile to 5 or 6 miles and forms an important source of groundwater. This groundwater area is particularly important in Louisville where the withdrawal rate exceeds 50 MGD and for Owensboro, groundwater is the source of the public water supply. An unique feature of the Louisville area is the ability to use seepage pits for waste disposal from private residences. This and one other area in the United States were known to be sites for such practice. The reason for this is a hard pan layer of clay which prevents the interchange of seepage pit waste into the groundwater aquifer. Another important geological feature is the occurrence of large coal reserves and to some extent petroleum resources, with extensive mining in Hopkins County. The coal reserves are shallow and strip mining can be practical for many of the coal seams present.

D. Hydrology

Tygarts Creek and the Tradewater have no locks or dams.

The Little Sandy River has an impoundment near Grayson Kentucky. The resultant lake, Grayson Reservoir, is used for flood control, recreation, fish and wildlife, and low flow augmentation. The lake has a volume of 10,600 acre feet and an area of 1,500 acres.

E. Population

The population of the basin in Kentucky was 993,011 in the year 1970 according to the U. S. Census. The largest city in this area is Louisville with a population of 358,000. Other population centers are Ashland, Northern Kentucky (principally the cities of Covington, Newport), Owensboro, Henderson and Paducah. All of these cities discharge into the Ohio River and not into their minor tributary basins. The population in the minor tributaries is predominately urban because of the Ohio River cities. Four (4) of Kentucky's five (5) SMSAs are along the Ohio River, the exception being Lexington. As the result of the population concentration and water pollution problems in the Ohio River, the complexes of Louisville and Northern Kentucky (principally the cities of Covington and Newport) are being studies under an Areawide Wastewater Management Plan (Section 208 of Public Law 92-500) and the Ashland-Huntington area is included in an Urban Studies project of the Corps of Engineers.

TABLE B-3

SURFACE WATER RECORDS FOR THE OHIO RIVER BASIN-MINOR TRIBUTARIES

STATION	PERIOD OF RECORD	DRAINAGE AREA	AVERAGE FLOW	MAXIMUM FLOW	MINIMUM FLOW	7-day/10-yr. LOW FLOW
Little Sandy River Below Grayson Dam near Leon**	10 yr.	196 sq.mi.	255 cfs, 1.3 cfs*/sq.mi.	5,600 cfs, 29 cfs/sq.mi.	0 cfs.	0 cfs.
	wtr/yr 1976		201 cfs, 1.0 cfs/sq.mi.	1,790 cfs, 9.1 cfs/sq.mi.	16 cfs, 0.1 cfs/sq.mi.	
Tygarts Creek near Greenup	36 yr.	242 sq.mi.	305 cfs, 1.3 cfs/sq.mi.	14,800 cfs, 61 cfs/sq.mi.	0 cfs.	0 cfs.
	wtr/yr 1976		258 cfs, 1.1 cfs/sq.mi.	8,380 cfs, 35 cfs/sq.mi.	3.8 cfs, 0.02 cfs	
Tradewater River at Olney	36 yr.	255 sq.mi.	329 cfs, 1.3 cfs/sq.mi.	13,600 cfs, 53 cfs/sq.mi.	0 cfs.	0 cfs.
	wtr/yr 1976		363 cfs, 1.4 cfs/sq.mi.	6,550 cfs, 26 cfs/sq.mi.	0.5 cfs, 0.0 cfs/sq.mi.	

* Cubic feet per second

** Flow regulated since July 1, 1968 by Grayson Lake.

NOTE: Data is taken from "Surface Water Records in Kentucky" by the United States Geological Survey. The 7-day/10-yr. low flow was taken from the waste load allocation produced as a component of the 303e River Basin Continuing Planning Process.

II. Basin Water Quality

A. Description of Water Sampling Stations

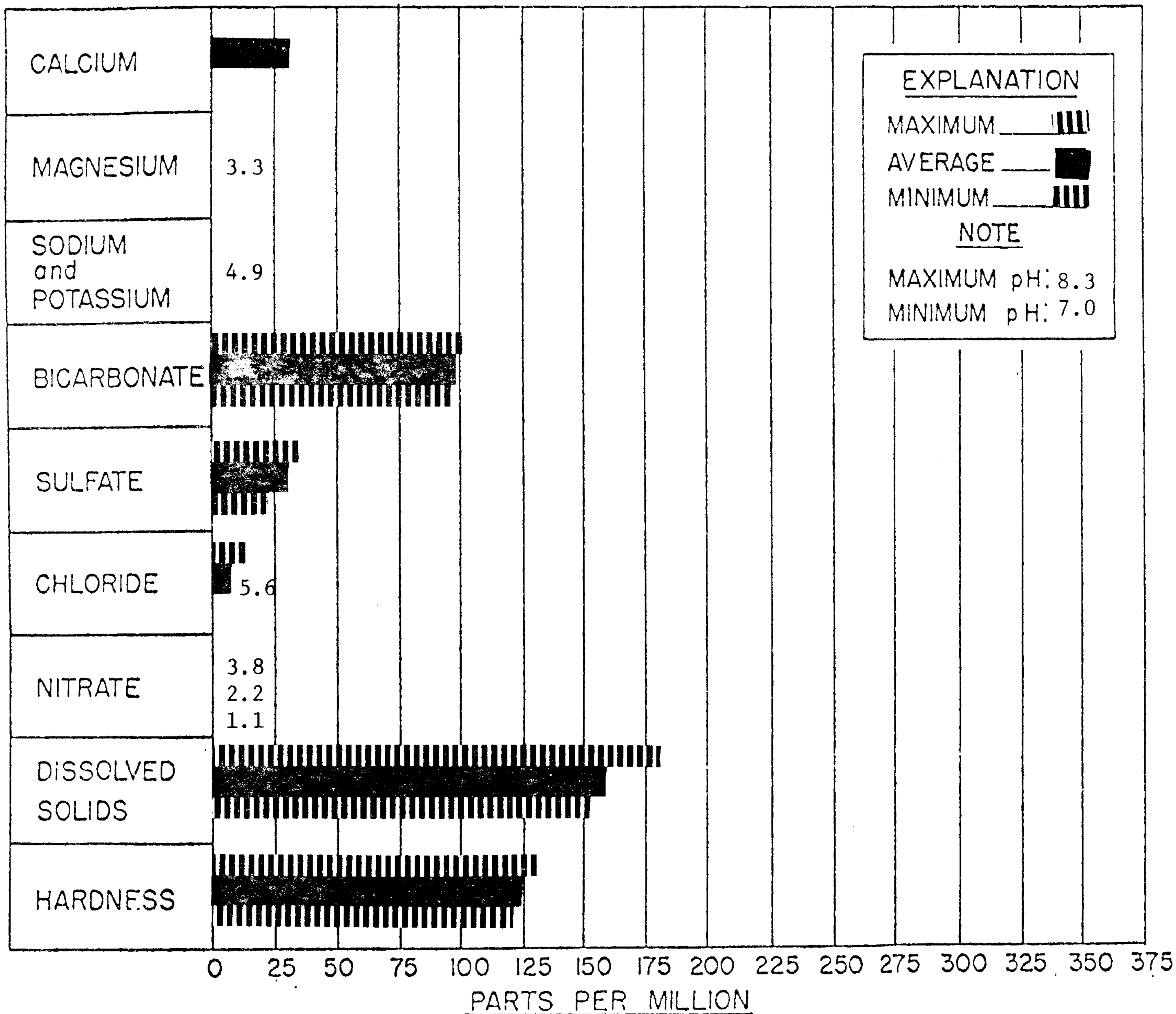
Examination of the character of the water in the minor tributaries was made by selecting two sampling stations. One on Tygarts Creek near Greenup Kentucky was selected since it most closely relates to the water quality through the basin. The other station was selected on the Tradewater River since it reflects the condition of a river which is subjected to acid mine drainage.

B. General Chemical Water Quality - Tygarts Creek and Tradewater River

The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The type of rock formation which the surface waters contact cause the predominate chemical characteristics when measured over a year period. The contribution of groundwater, which is generally higher in dissolved solids, than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky are ones which have moderate hardness caused by calcium and magnesium salts. The influence of mining activities are clearly indicated when the sulfate content increases higher than the bicarbonate content, and the pH is on the acid side, below pH 5.5.

Oil field operations, when brine is encountered, are reflected by changes in sodium and chloride contents of the water. For Kentucky water, the influence is pronounced when either chloride or sodium exceeds 20 -25 parts per million as an average value.

The water quality in Tygarts Creek near Greenup shown in Figure B-1 is typical of the water quality throughout the minor tributaries with the exception



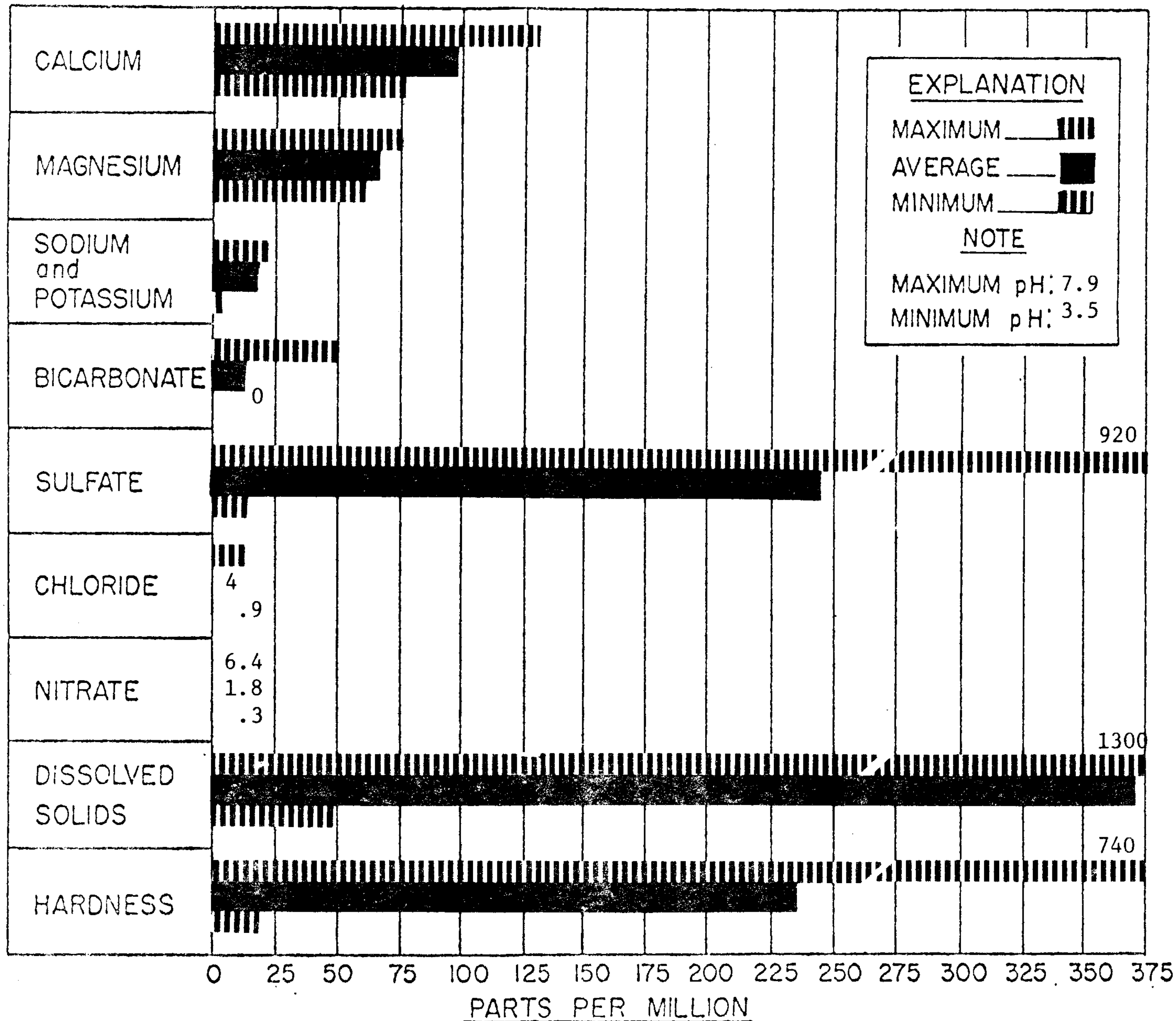
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE B-1

Tygarts Creek

Greenup

9-70 to 8-74



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE B-2

Tradewater River

Olney

3-70 to 9-73

of waters which are affected by acid mine drainage. The water in Tygarts Creek is of the calcium bicarbonate type, reasonably stable as viewed from the average to the maximum change in water quality, and slightly on the alkaline side with a pH in excess of a neutral 7. This water is hard, but softening for domestic purposes can be done through the lime softening process.

The Tradewater River was selected to show the effects of acid mine drainage on a watershed. Figure B-2 clearly illustrates this effect. The sulfate content is excessive with an average value of 240. The total dissolved solids content is near the water quality standard and the water is extremely hard. Further, this water exhibits very poor stability in that on occasions dissolved solids are five times the average and the pH shows a wide variation from 3.5 to 7.9. This water has very little buffering capacity as shown by the bicarbonate content which has been depleted by acid mine drainage effects.

C. Trace Chemical Water Quality

Trace elements are separated from the general chemical background of this report because of their influence on human health. Cenerally, these materials are "heavy" metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State-Federal Water Quality Standards.

Excessively high levels of manganese were noted for six occasions on the Tradewater River at Olney. The analytical procedures will be modified to reflect the total and dissolved trace elements.

D. Waste Load Effect on Water Quality
(Tradewater and Little Sandy Rivers and Tygarts Creek)

Waste loads are considered to have an effect on water quality when they cause the dissolved oxygen concentration (D.O.) of the water to drop below the Kentucky Water Quality Standard of 5.0 milligrams per liter (mg/l).

Approximately 430 miles of stream length were studied under a model developed in the Kentucky Continuing Planning Process for River Basin Management Planning, used to determine waste load allocation. Using this model it was determined that 85 miles of that length would have a D.O. concentration of less than 5.0 mg/l when the flow is equal or less than the 10 year 7 day low flow. Of the stream length affected,eight miles (9 per cent) are by industrial discharge and 36 miles (42 per cent) are affected by municipal discharge. The remaining 41 miles (48 per cent) are affected by discharge from places such as schools, trailer parks, and subdivisions, etc.

E. Non-Point Source Effects Ohio River Kentucky Portion

Major non-point source pollutants of the basin's streams are sediment, agricultural pesticides, solid waste, and animal waste.

Excessive sediment is a result of erosion on surface mined areas, agricultural lands, forest lands, roadbanks, streambanks, construction, and developing areas.

Major erosion sources are summarized as follows:

1. Approximately 452 square miles of the basin's cropland have average erosion rates in excess of acceptable limits.

2. Much erosion is from about 531 square miles of disturbed forest lands. This comprises about 63 per cent of the erosion from forest lands while including about 20 per cent of the total forest lands.

3. An estimated 125 square miles of land in the basin are affected by gully erosion.

4. An estimated 3 square miles per year are being disturbed for industrial and urban expansion.

F. Water Uses

Water use in the minor tributaries from either surface or groundwater is limited since only eight small cities use water from these minor tributaries. There are, also, limited water uses for industrial purposes.

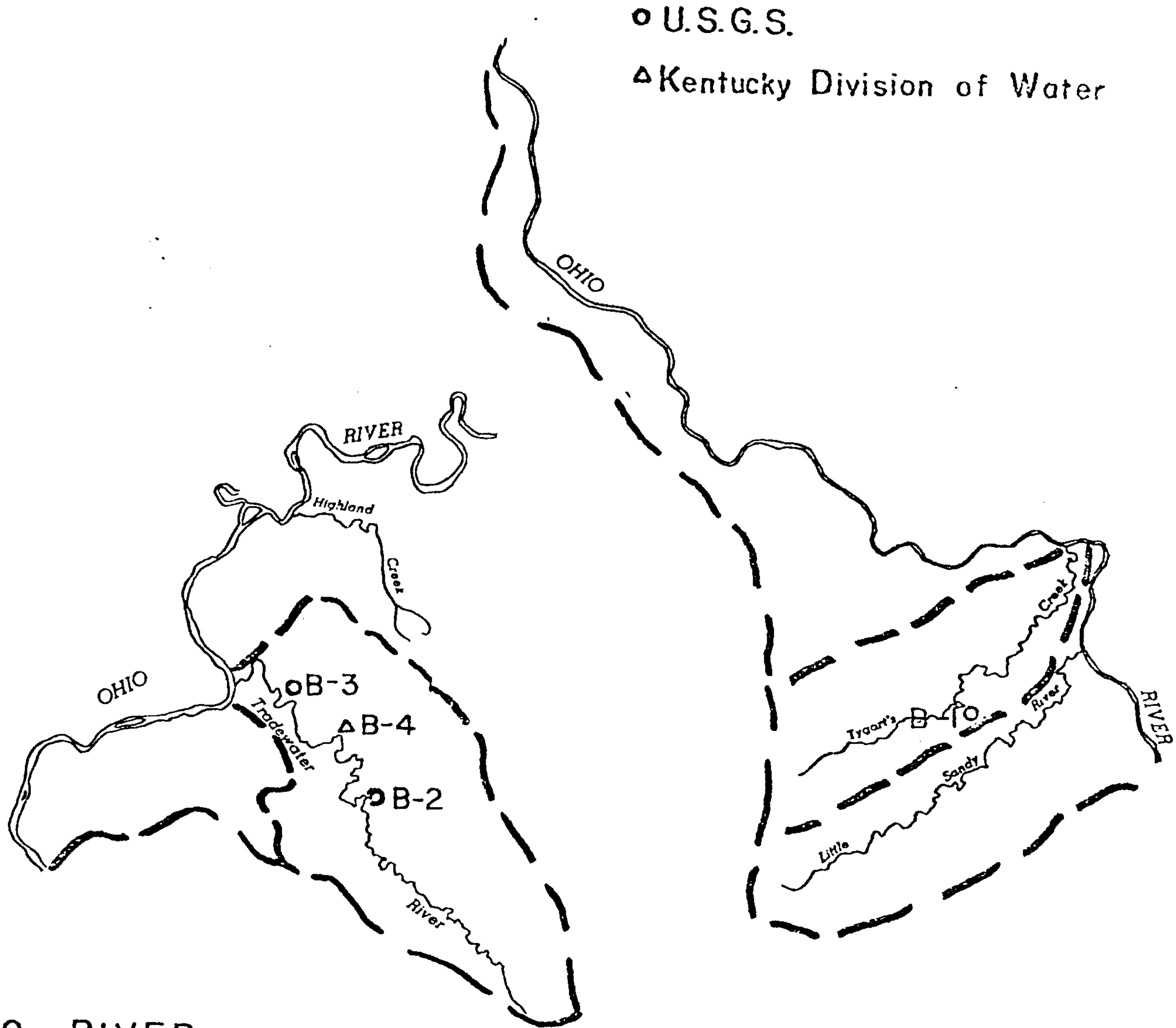
G. Water Quality Changes

The only area where water quality changes are expected in the minor tributaries of the Ohio River are in the Tradewater River Basin and the area of Union County where extensive coal resources exist. This change is anticipated due to the increased demand for coal. Some water quality change will result in the upgrading of waste treatment facilities.

III. Water Quality Causes and Corrections in the Tradewater and Little Sandy Rivers and Tygarts Creek

In the Little Sandy River and Tygarts Creek, the main problems are siltation and organic waste loads. Siltation is mainly from erosion and run-off due to improper agricultural and timbering practices. With the increase in interest for modern farming methods this problem should decrease. The organic waste loads, due to lack of proper treatment facilities, can be alleviated by upgrading treatment methods.

The main problem in the Tradewater River is acid mine drainage and siltation from the coal mining industry. This siltation is the result of two practices, strip mining which causes upheaval of the surface land, and logging which can result in high runoff rates and serious erosion. With the increase in demand for coal due to the energy crisis, great care and vigilance will need to be exercised to see that this problem does not increase.



OHIO RIVER

STATION KEY

B-1	TYGARTS CREEK NEAR GREENUP
B-2	TRADEWATER RIVER AT OLNEY
B-3	TRADEWATER RIVER AT SULLIVAN
B-4	TRADEWATER RIVER HIGHWAY 120

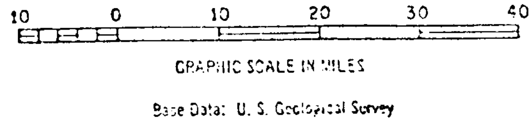


TABLE B-1

TOTAL DRAINAGE AREA OF OHIO RIVER BASIN IN KENTUCKY
(Excluding the following rivers: Kentucky, Salt, Green, Big Sandy, Licking, Cumberland and Tennessee

STREAM	DRAINAGE AREA (square miles)
Ohio River:	
Ohio River	6090
Tradewater River	940
Little Sandy River	720
Tygarts Creek	340
Kinniconik Creek	250

TABLE B-2

SLOPE CHARACTERISTICS OF THE LITTLE SANDY AND TRADEWATER RIVERS AND TYGARTS CREEK

STREAM	Average slope (ft./mi.)	Slope in lower 20 miles (ft./mi.)	Slope in lower 70 miles (ft./mi.)
Little Sandy River	8.3		1.7
A. East Fork	11.9	2.6	
B. Little Fork	15.2	3.5	
Tygarts Creek	6.9		3.3
Tradewater River	1.3		0.7

TABLE B-4

Population of the Ohio River Basin in Kentucky

County	Population in 1970**	Population in basin *
Ballard	28,677	23,400
Boone	32,812	32,650
Boyd	52,376	43,600
Bracken	7,227	4,850
Breckinridge	14,789	10,200
Caldwell	13,179	3,600
Campbell	88,561	79,000
Carroll	8,523	1,600
Carter	19,850	19,850
Christian	56,224	5,400
Crittenden	8,493	7,300
Daviess	79,486	55,500
Elliott	5,933	5,700
Gallatin	4,134	4,134
Greenup	33,192	33,192
Hancock	7,080	6,400
Hardin	78,421	32,600
Henderson	36,031	32,600
Henry	10,910	3,350
Hopkins	38,167	10,200
Jefferson	695,055	371,700
Kenton	129,440	80,500
Lawrence	10,726	760
Lewis	12,355	11,450
Livingston	7,596	2,970
Mason	17,273	10,300
McCracken	58,281	41,800
Meade	18,796	18,696
Oldham	14,687	8,900
Pendleton	9,949	600
Rowan	17,010	1,000
Trimble	5,349	3,500
Union	15,882	15,882
Webster	13,282	9,700
	Total	992,990*

* Approximate measurement ± 10 per cent based on U.S. Census Data

** U. S. Census Data

Table B-5

City Population and Facility Grant Status
in the Ohio River Basin in Kentucky

County	City	Population	Project Type	Comments
Ballard	(Barlow)	746	1	Active
	(Kevil)	274	1	Active
Boone	Florence	11,661	None	Sewers/STP
	Petersburg	430	None	No Sewers
	Boone Co. W & S (Burlington)	350	1	Active
Boyd	Ashland	29,200	1	Active
	(Sanitation District #1 Boyd-Greenup)		1	Active
Bracken	Augusta	1,434	1	Active
	Germantown	332	None	No Sewers
Breckinridge	Cloverport	1,388	None	Sewers/STP
	Hardinsburg	1,547	1	Active
	Irvington	1,300	1	Active
Caldwell				
Campbell				
Carroll	Ghent	381	None	No Sewers
Carter	Grayson	2,184	1	Active
	Olive Hill	1,197	1	Active
Christian				
Crittenden	Marion		None	Sewers/STP
Daviess	Owensboro	51,400	1	Active
Elliott	Sandy Hook	192	None	No Sewers
Gallatin	Warsaw	1,232	1	Active
Greenup	(Bellefonte)		1	Active
	County Env. Comm.		1	Active
			2	Pending
	(Flatwoods)	7,380		
	(Raceland)	1,857		
	(Worthington)	1,364		
	(Greenup)	1,284		
	(Worthland)	1,000		
	South Shore	676	None	Sewers/STP

Table B-5
Continued

County	City	Population	Project Type	Comments
Hancock	Hawesville	1,262	1	Active
	Lewisport	1,595	1	Active
Hardin	(Vine Grove)	2,987	1	Active
	West Point	1,741	2	Active
Henderson	Henderson-	23,100	1	Active
	(Corydon)	880		
Henry	Campbellsburg	479	1	Active
Hopkins	Dawson Springs	3,009	1	Active
	St. Charles	373	None	No Sewers
Jefferson	Louisville	361,958	1	Active
			2 & 3	Pending
Kenton	Sanitation District #1		3	Active
	Campbell-Kenton			
	Taylor Mill	3,194	None	No Sewers
Lawrence				
Lewis	Vanceburg	1,773	None	Sewers/STP
Livingston				
Mason	Maysville-	7,200	1	Active
	(Washington)	439		
McCracken	Paducah	31,200	1	Active
	(Sanitation District #1/2)	3,500		
Meade	Brandenburg	1,637	3	Pending
Oldham	LaGrange	1,713	1	Active
	Oldham Co. W. D. No.1		1	Active
Pendleton				
Rowan				
Trimble	Bedford	780	1	Active
	Milton	756	1	Active
Union	Morganfield	3,563	1	Active
	(Waverly)	335		
	Sturgis	2,210	1	Active
	Uniontown	1,255	None	Sewers/STP

Table B-5
Continued

County	City	Population	Project Type	Comments
Webster	Providence	4,270	1	Active
	Clay	1,426	1	Active
	(Wheatcroft)	229		No Sewers
	Dixon	572	None	No Sewers

NOTE: Project type is related to the grant process step applied for or active for each municipality. Step 1 is the preliminary studies (201 Facilities Plan) required before design of the facilities. Step 2 is the design phase of the project, and Step 3 is the construction of facilities for the collection and treatment of wastewaters.

The comments relate to the status of the grant. Active indicates the project is funded and underway. Pending indicates that application for a grant has been made and is pending approval. No sewers indicates that the municipality does not presently have a comprehensive sewer system. Sewers/STP indicates the municipality is now served by sewers and treatment facilities.

The source of this information was the 1970 U. S. Census and the FY 77 construction grants list for Kentucky.

Table B-6

Water Quality Data for Ohio River Basin

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
STORET #00400	pH Specific Units, Ky. std. 6 LT pH LT 9						
Tygarts Cr., Greenup	70/09/10	72/09/06	7.5	8.3	7.0	3	.681
USGS #03217000	65/05/22	72/09/06	7.5	8.3	7.0	4	.560
	60/04/28	72/09/06	7.4	8.3	7.0	6	.485
Tradewater R., Olney	70/03/05	73/09/30	6.3	7.9	3.5	86	1.067
USGS #03383000	69/10/01	70/02/16	5.9	7.5	4.5	10	1.264
	69/03/26	69/09/02	5.6	7.2	3.9	12	1.276
	68/05/15	69/02/22	5.8	7.9	3.8	19	1.489
	68/03/22	68/04/28	6.9	7.3	6.2	3	0.608
STORET #00095	Conductivity Micro mhos, Ky. Std. 800 micro mhos						
Tygarts Cr., Greenup	75/02/16	75/06/24	190	250	120	3	65.6
	70/09/10	74/08/11	233	300	147	7	55.0
	65/05/22	74/08/11	232	300	147	8	51
	60/04/28	74/ 6/ -	210	300	100	9	61
Tradewater R., Olney	70/03/05	73/09/30	500	1570	50	86	333.3
	69/10/01	70/02/16	475	899	109	10	301.5
	69/03/26	69/09/02	579	1610	60	12	467.1
	68/05/15	69/02/22	662	1440	109	19	431.2
	68/03/22	68/04/28	259	507	114	3	215.8
Tradewater R., Sullivan	76/02/17	76/11/23	1062	2500	400	4	967.3
USGS #03384180	75/08/27	76/11/23	978	2500	400		800.0
STORET #70300	Residue mg/l (milligrams per liter), Ky. Std. 500 mg/l						
Tygarts Cr., Greenup	70/09/10	72/09/06	166	180	152	3	14.0
	60/04/28	72/09/06	136	180	71	5	44.7
Tradewater R., Olney	70/03/05	73/09/30	373	1300	48	86	287.6
	69/10/01	70/02/16	353	695	74	10	242.4
	69/03/26	69/09/02	445	1410	56	12	412.6
	68/05/15	69/02/22	518	1260	90	19	380.0
	68/03/22	68/04/28	186	362	88	3	152.7
STORET #00410	Alkalinity mg/l, No standard						
Tygarts Cr., Greenup	70/09/10	72/09/06	99	101	97	3	2.1
	60/04/28	72/09/06	81	101	35	5	28.0

Table B-6
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
Tradewater R., Olney	70/03/05	73/09/30	13	49	0	86	10.2
	69/10/01	70/02/16	6	16	0	10	6.6
	69/03/26	69/09/02	6.7	20	0	12	7.2
	68/05/15	69/02/22	7.5	23	0	19	7.0
	68/03/22	68/04/28	13	16	7	3	5.2
STORET #00900	Hardness mg/l, 0-60 Soft, 61-120 Mod. Hard, 121-180 Hard, 180+ Very Hard						
Tygarts Cr., Greenup	70/09/10	72/09/06	125	130	120	3	5.0
	65/05/22	72/09/06	119	130	102	4	12.1
	60/04/28	72/09/06	102	130	47	6	31.0
Tradewater R., Olney	70/03/05	73/09/30	235	740	15	86	165.5
	69/10/01	70/02/16	222	447	42	10	157.1
	69/03/26	69/09/02	278	772	25	12	240.9
	68/05/15	69/02/22	305	729	43	19	213.8
	68/03/22	68/04/28	115	238	44	3	107.2
STORET #00080	Color Platinum Cobalt Units, Prop. EPA Std.75 Units						
Tygarts Cr., Greenup	65/05/22	65/05/22	3			1	
	60/04/28	65/05/22	20	50	3	3	26.1
Tradewater R., Olney	71/11/25	72/10/30	10	15	5	3	5.0
	69/11/12	69/11/21	17.5	30	5	2	17.7
	68/11/23	68/11/23	5			1	
STORET #00930	Sodium mg/l, No Standard						
Tygarts Cr., Greenup	60/04/28	60/04/28	3.8			1	
Tradewater R., Olney	70/11/04	72/11/05	13	14	12	4	0.82
	69/11/12	69/11/12	15			1	
	68/11/23	68/11/23	18			1	
STORET #00935	Potassium mg/l, No Standard						
Tygarts Cr., Greenup	60/04/28	60/04/28	1.1			1	
Tradewater R., Olney	70/11/04	72/11/05	4.8	5.2	4.4	4	0.34
	69/11/12	69/11/12	3.4			1	
	68/11/23	68/11/23	5.1			1	

Table B-6
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
STORET #00940	Chloride mg/l, Proposed EPA Std. 250 mg/l						
Tygarts Cr., Greenup	70/09/10	72/09/06	8.5	13.0	5.6	3	3.97
	65/05/22	72/09/06	7.3	13.0	4.0	4	3.94
	60/04/28	72/09/06	6.0	13.0	1.0	6	
Tradewater R., Olney	70/03/05	73/09/30	4.0	11.0	0.9	86	1.68
	69/10/01	70/02/16	6.6	10.0	3.0	10	2.62
	69/03/26	69/09/02	5.5	21.0	2.0	12	5.18
	68/05/15	69/02/22	5.1	10.0	1.0	19	2.45
	68/03/22	68/04/28	3.5	5.0	2.5	3	1.32
STORET #00945	Sulfate mg/l, Proposed EPA Std. 250 mg/l						
Tygarts Cr., Greenup	70/09/10	72/09/06	27	31	23	3	4.04
	65/05/22	72/09/06	26	31	23	4	3.40
	60/04/28	72/09/06	24	31	14	6	5.56
Tradewater R., Olney	70/03/05	73/09/30	229	920	12	85	194.7
	69/10/01	70/02/16	223	480	31	10	166.2
	69/03/26	69/09/02	292	990	12	12	287.9
	68/05/15	69/02/22	339	360	29	19	266.3
	68/03/22	68/04/28	105	233	32	3	111.0
STORET #71851	Nitrate mg/l, Prop. EPA Std. 10 mg/l						
Tygarts Cr., Greenup	70/09/10	72/09/06	2.2	3.8	1.1	3	1.44
	65/05/22	72/09/06	1.7	3.8	0.2	4	1.53
	60/04/28	72/09/06	1.4	3.8	0.2	5	1.44
Tradewater R., Olney	70/03/05	73/09/30	1.8	6.4	0.3	86	0.91
	69/10/01	70/02/16	1.6	2.6	0.3	10	0.86
	69/03/26	69/09/02	1.4	2.8	0.5	12	0.82
	68/05/15	69/02/22	0.6	1.2	0.2	19	0.36
	68/03/22	68/04/28	1.3	2.0	0.7	3	0.67
STORET #00950	Fluoride mg/l, Ky. Std. 1.0 mg/l						
Tygarts Cr., Greenup	70/09/10	72/09/06	0.10	0.10	0.10	3	0.000
	60/04/28	72/09/06	0.12	0.20	0.10	4	0.050
Tradewater R., Olney	70/11/04	73/02/26	0.42	0.90	0.10	8	0.276
	69/11/12	69/11/17	0.50			1	
	68/11/23	68/11/23	1.20			1	

Table B-6
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
STORET #00915	Calcium mg/l, No Standard						
Tygarts Cr., Greenup	60/04/28	60/04/28	30			1	
Tradewater R., Olney	70/11/04	72/11/05	95	130	76	4	25.5
	69/11/12	69/11/12	90			1	
	68/11/28		140			1	
STORET #00925	Magnesium mg/l, No Standard						
Tygarts Cr., Greenup	60/04/28	60/04/28	3.3			1	
Tradewater R., Olney	70/11/04	72/11/05	64	76	58	4	8.02
	69/11/12	69/11/12	54			1	
	68/11/23	68/11/23	92			1	
STORET #01025	Cadmium ug/l (Micrograms per liter), Ky. Std. 100 ug/l						
Tygarts Cr., Greenup	75/02/16	75/06/24	0.7	2.0	0.0	3	1.15
	74/04/10	74/09/20	1.2	3.0	0.0	5	1.10
Tradewater R., Sullivan	76/02/17	76/11/23	5.0	12.0	2.0	4	4.76
	75/08/27	76/11/23	3.7	12.0	2.0	6	4.27
STORET #01056	Manganese ug/l, Prop. Ky. Std. 50 ug/l						
Tradewater R., Olney	70/03/05	73/09/30	2958	24000	0.0	84	4836
	69/10/01	70/02/16	4827	11000	0.0	10	4486
	69/03/26	69/09/02	4652	17000	0.0	12	5560
	68/05/15	69/02/22	5547	18000	0.0	19	5637
	68/03/22	68/04/28	1070	3200	0.0	3	1845
STORET #01046	Iron ug/l, Prop. EPA Std. 300 ug/l						
Tradewater R., Olney	70/03/05	73/09/30	49	730	0	84	92.9
	69/10/01	70/02/16	135	570	20	10	164.9
	69/03/26	69/09/02	177	1200	0	12	341.1
	68/05/15	69/02/22	89	480	10	19	112.1
	68/03/22	68/04/28	80	150	0	3	
STORET #01030	Chromium ug/l, Ky. Std. 50 ug/l						
Tygarts Cr., Greenup	75/02/16	75/06/24	0.3	1.0	0.0	3	0.577
	74/04/10	74/09/20	0.2	1.0	0.0	5	0.447

Table B-6
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
Tradewater R., Sullivan	76/02/17	76/11/23	1.5	6.0	0.0	4	3.0
	75/08/27	76/11/23	1.0	6.0	0.0	6	2.5
STORET #01049	Lead ug/l, Ky. Std. 50 ug/l						
Tygarts Cr., Greenup	75/02/16	75/06/24	5.7	7.0	5.0	3	1.155
	74/04/10	74/09/20	6.6	19.0	0.0	5	7.537
Tradewater R., Sullivan	76/02/17	76/11/23	7.8	11.0	4.0	4	2.872
	75/08/27	76/11/23	6.2	11.0	0.0	6	3.817
STORET #01000	Arsenic ug/l, Ky. Std. 50 ug/l						
Tygarts Cr., Greenup	75/02/16	75/06/24	0.0	0.0	0.0	3	0.0
	74/04/10	74/09/20	1.2	5.0	0.0	5	2.168
Tradewater R., Sullivan	76/02/17	76/11/23	0.25	1.0	0.0	4	.5
	75/08/27	76/11/23	0.17	1.0	0.0	6	.408
STORET #31503	Total Coliform Count Per 100 ml., Ky. Std. 1000 Per 100 ml.						
Tradewater R. Hwy. 120	75/01/07	75/12/15	1402	7400	15	12	
	74/07/23	75/12/15	1301	4700	15	13	
	74/04/30	74/09/04	820	2870	0	9	
STORET #31616	Fecal Coliform Count Per 100 ml.						
Tradewater R. Hwy. 120	75/12/15	75/12/15	3780			1	

TABLE B-8

Water Withdrawal - Ohio River Basin

	Source	SW*	GW**	(Million Gallons/Day) Public	Industrial
Boyd					
Ashland Mun. Water Works	Ohio River	x		3.442	1.475
Breckinridge					
Hardinsburg Mun. W. W.	Hardins Ck. Reservoir	x		.124	.001
Campbell					
Newport Municipal W. W.	Ohio River	x		5.065	.894
Carter					
Grayson Utility Comm.	Little Sandy	x		.282	
Olive Hill Mun. W. W.	Reservoir on Perry Branch	x		.166	.002
Carter Caves State Park	Tygarts Creek	x		.032	
Crittenden					
Marion Municipal W. W.	Reservoir	x		.264	.088
Greenup					
Greenbo Lake State Park	Greenbo Lake	x		.008	
Russell - C & O Railroad	Ohio River Wells (3)	x	x		.100 GW .900 GW
Wurtland - E.I. Dupont DeNemours Co.	Ohio River Wells (2)	x	x		.034 GW 5.400 SW
Hardin					
Ft. Knox	Otter Creek 12 wells	x	x	4.711 GW 2.385 SW	.523 GW .265 SW
Vine Grove	Otter Creek & Brushy Fk.	x		.233	
Henderson					
Henderson Municipal W. W.	Ohio River	x		3.090	.421
Henderson Farmers Tankage	Ohio River	x			.421
Jefferson					
Louisville Water Co.	Ohio River	x		62.290	52.271
Airco Alloys & Carbide	Ohio River & 6 wells	x	x		2.100 GW 8.000 SW
E.I. Dupont DeNemours Co.	Ohio River & 10 wells	x	x		5.641 GW 68.515 SW

	Source	SW*	GW**	(Million Gallons/Day) Public	Industrial
Kenton					
Covington Municipal W. W.	Ohio River	x		5.800	1.800
McCracken					
Paducah Municipal W. W.	Ohio River	x		4.641	.819
Shawnee Steam Plant	Ohio River	x		.028	1.581
Mason					
Maysville Utility Comm.	Ohio River	x		.748	.499
Meade					
Otter Creek Park	Otter Creek	x		.047	
Oldham					
LaGrange Municipal W. W.	Brush Creek Reservoir	x		.479	.084
Union					
Morganfield Water Works	Ohio River	x		.650	
Hamilton Mine	Ohio River				.031
DeKovin Mine	Denis O'Nan Reservoir and well	x	x		.030 GW .170 SW
Uniontown Municipal W. W.	Ohio River	x		.102	.005
			Total SW	92.261	143.642
			Total GW	4.711	8.394

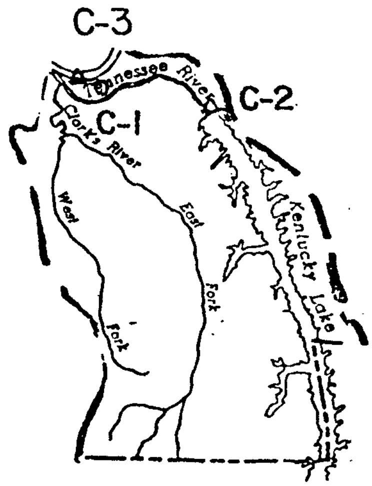
*Surface water
**Ground water

TABLE B-9

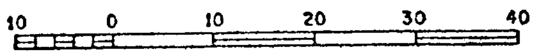
Organic Loads Affecting Streams in the Ohio River Basin

Length of streams to which treated organic loads are discharged		431 miles
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow		85 miles
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow due to	Municipal Discharges	36 miles
	Industrial Discharges	8 miles
	Other Discharges	41 miles

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e River Basin Planning effort. The values indicated the stream miles in which the dissolved oxygen is predicted to be less than 5 mg/l when the stream flow is less than the once in ten year, seven day, low flow.



TENNESSEE RIVER



GRAPHIC SCALE IN MILES

Base Data: U. S. Geological Survey

THE TENNESSEE RIVER BASIN

The Kentucky portion of the Tennessee River basin makes up the eastern half of an area in the far western corner of the state called the Jackson Purchase region (named after General Andrew Jackson who, in 1818, arranged the purchase treaty with the Chickasaw Indians). The Jackson Purchase region is unique in many respects from the rest of Kentucky. This report will discuss first the Tennessee River basin in general in this region of Kentucky, and secondly discuss existing water quality in the area and the factors that influence water quality in the basin.

I. Basin Description

A. Geography

The Tennessee River joins the Ohio River near Paducah, Kentucky, at mile point 46.9 of the Ohio. The Tennessee River crosses the Kentucky-Tennessee border at mile point 51.1 and continues along the border to mile point 62.3, where it leaves Kentucky.

The basin encompasses all or portions of the following counties in Kentucky: Calloway, Graves, Livingston, Lyon, Marshall, McCracken, and Trigg. Of the total drainage area for the river of 40,330 sq. mi., approximately 1,000 sq. mi. are in Kentucky. (See Table I) The one major tributary to the Tennessee River in Kentucky is the Clarks River, which has a total drainage area of 530 sq. mi. The remaining area drains directly into the Tennessee River.

B. Topography

Low hills comprise the headwater areas which become rolling hills, then abruptly change to a flood plain as it nears the main stem. Elevations vary from

300 to 620 feet above sea level, with an average slope in the East Fork of Clark's River of 4.6 ft./mi., and 7.0 ft./mi. in the West Fork. The main stem of the Tennessee River to mile point 22 is within the influence of the Lock and Dam 52 on the Ohio with a pool elevation of 302. At mile point 22 Kentucky Dam forms Kentucky Lake and the pool extends into Tennessee to the Pickwick Landing Dam.

C. Geology

The geology of the area is made up of 4 major types of formations, all of which are primarily sand and clay mixtures, with gravel and silt in varying amounts. The bedrock of the area consists of limestone, chert, and dolomite.

The sand and clay formations are generally sources of good quality groundwater. Groundwater from the bedrock is often high in iron content, and can be treated if necessary before use. Generally, the groundwater quality is consistently good and may yield as much as 1,700 gallons per minute (g.p.m.). For these reasons it is a valuable source of domestic and industrial water supply in the basin.

D. Hydrology

The Tennessee River itself is a highly developed river system, with a series of locks and dams from near the mouth to the upper headwaters. Also, for navigation and for better flow regulation a canal was built between Lake Barkley and Kentucky Lake. The impoundment of the Tennessee River has resulted in superb regulation and increased the minimum daily flow from 5000 cfs to in excess of 20,000 cfs.

Flow in the Clarks River is not regulated or augmented by dams and reservoirs.

Flow measurements have been taken on the main stem of the Tennessee River and on both the East and West Forks of Clark's River. These recorded flows are depicted in Table C-6 on the following page.

Periodically, flow on the main stem of the Tennessee River below Kentucky Dam goes to zero due to maintenance and operation of the turbines for hydroelectric power generation. These flow outages do not exceed 7 days, and impounding provisions for waste discharges are provided to accommodate this flow outage.

Kentucky Lake is the only lake of note in the Tennessee River basin in Kentucky. It is a multi-purpose reservoir, for flow augmentation, flood control, hydroelectric power production, and recreation. The lake's maximum capacity is 7,415,000 acre feet, covering an average area of 306,000 acres.

E. Population

The total population in the Tennessee River basin in Kentucky is 68,412. Murray, Kentucky, in Calloway County, with a population of 13,700 is the largest city in the area. Seven smaller communities make up the rest of the urban population which totals 25,277. This represents 37 per cent of the total population. The remainder of the population is located in rural areas. The urban distribution is shown in Table C-3.

Population in a basin is an important factor in the water quality of the basin, as water is used for a great variety of purposes, then discharges back into the streams. Influence of waste discharges are discussed in the second part of this report.

TABLE C-6

SURFACE WATER RECORDS FOR THE TENNESSEE RIVER BASIN

STATION	PERIOD OF RECORD	DRAINAGE AREA	AVERAGE FLOW	MAXIMUM FLOW	MINIMUM FLOW	7-day/10-yr. LOW FLOW
Tennessee River near Paducah	76 yr.**	40,200 sq.mi.	64,060 cfs, 1.6cfs*/sq.mi.	500,000 cfs, 12 cfs/sq.mi.	60 cfs, 0.0cfs/sq.mi.	712.0 cfs
	11 yr.**		66,410 cfs, 1.7cfs/sq.mi.	420,000 cfs, 10 cfs/sq.mi.	18,800 cfs, 0.5cfs/sq.mi.	
	wtr/yr 1976		57,250 cfs, 1.4cfs/sq.mi.	169,000 cfs, 4.2 cfs/sq.mi.	18,800 cfs. 0.5cfs/sq.mi.	
East Fork Clarks River near Benton	wtr/yr 1976***	227 sq.mi.		11,000 cfs, 48cfs/sq.mi.		2.2 cfs
West Fork Clarks River near Brewers	8 yr.	68.7 sq.mi.	98.8 cfs, 1.4cfs/sq.mi.	9,370 cfs, 136cfs/sq.mi.	1.2 cfs, 0.02cfs/sq.mi.	0.8 cfs
	wtr/yr 1976		95.7 cfs, 1.4cfs/sq.mi.	7,450 cfs, 108cfs/sq.mi.	2.5 cfs, 0.04cfs/sq.mi.	

* Cubic feet per second

** 76 Years (1889-1965), prior to opening of Barkley-Kentucky Canal.
10 Years (1965-1975), since opening of Barkley-Kentucky Canal.

*** Operated as a continuous-record gaging station 1938-73, and as a crest-stage partial-record station since 1974.

NOTE: Data is taken from "Surface Water Records in Kentucky" by the United States Geological Survey. The 7-day/10-yr. low flow was taken from the waste load allocation produced as a component of the 303e River Basin Continuing Planning Process.

II. Basin Water Quality

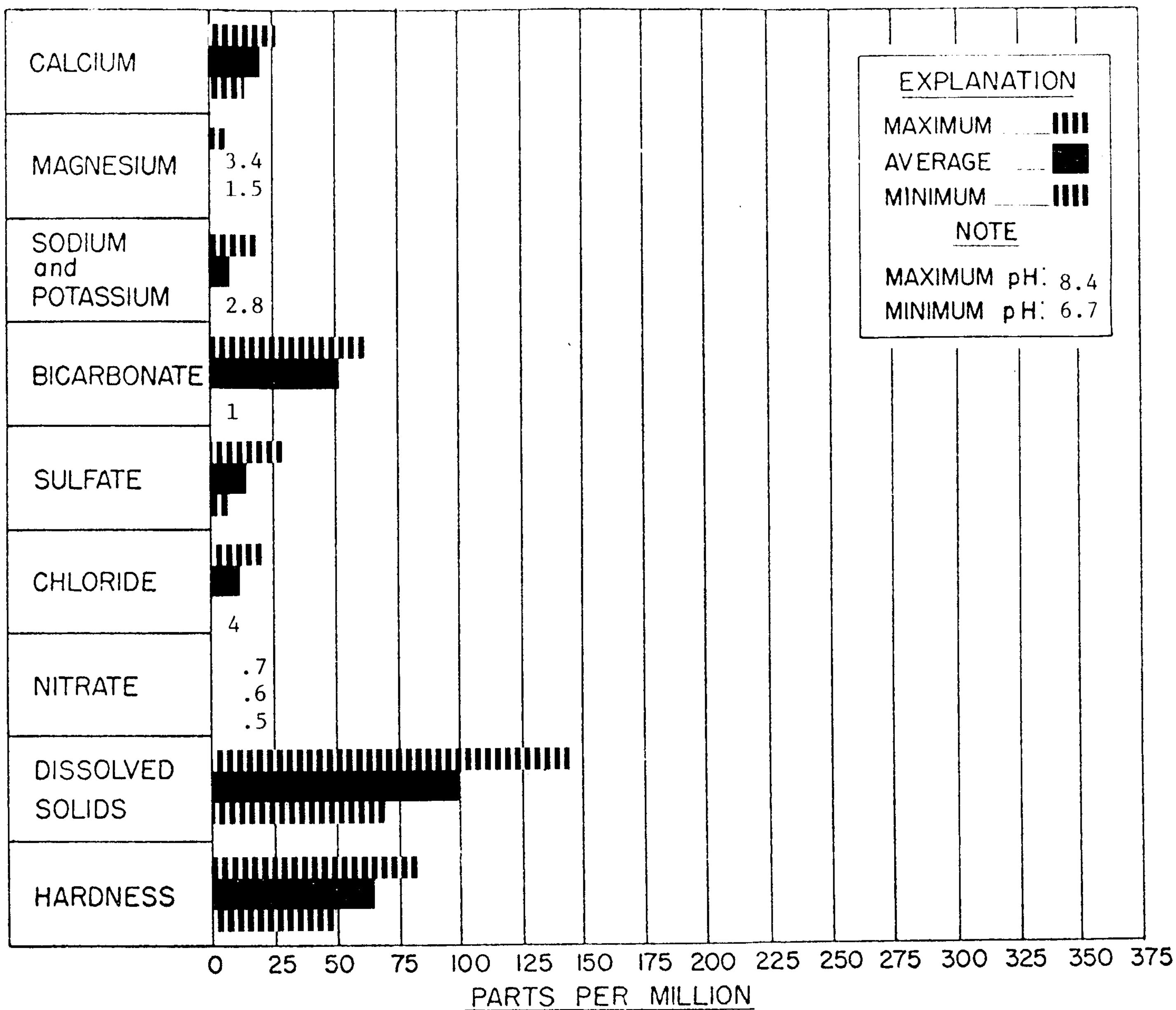
A. Description of Sampling Stations

Samples of the water, for testing its quality, were taken at a U.S.G.S. flow gauging station on the Tennessee River near Paducah, Kentucky. This is located in the far northern portion of the basin. Drainage area above the station is 40,200 sq. mi., representing almost the entire drainage area in the Tennessee River basin. Data obtained from this sampling and testing is listed in Table A-4 and Figure A-1.

B. General Chemical Water Quality

The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The chemical characteristics of a stream when viewed over a long period of time is primarily from surface water. The type of rock formation and soils which the surface water contacts causes this predominate chemical characteristic. The contribution of groundwater, which is generally higher in dissolved solids than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky is one of moderate hardness caused by calcium and magnesium salts.

In the main stem of the Tennessee River in Kentucky, the quality of the water is excellent. The impoundment of the water by Kentucky Dam has shown a marked stabilization effect on water quality values (little variation between maximum and minimum). This consistency of water quality is significant in that when water quality is stable, standards for effluent discharged into that water may be well defined, and more confidence can be placed in monitoring results. The data was insufficient to reach a conclusion concerning the water quality of Clarks River.



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE C-1

Tennessee River

Paducah

10-59 to 11-74

C. Trace Chemical Water Quality

Trace elements (under 5 mg/l) are separated from the general chemical background of this report because of their influence on human health. Generally, these materials are "heavy" metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State-Federal Water Quality Standards.

Trace chemicals in the surface water of the main stem of the Tennessee River in Kentucky were measured as being within Kentucky/Federal Water Quality Standards.

D. Waste Load Effects on Water Quality

Biochemically degradable wastes impose a load on the dissolved oxygen recourses of a stream. Such waste loads are considered to have an effect upon water quality when they cause the dissolved oxygen (D.O.) concentration to drop below the Kentucky Water Quality Standard of 5.0 mg/l. Based on a model developed for the Kentucky Continuing Planning Process for River Basin Management Planning, 248.0 miles of streams in the basin that receive waste discharges were evaluated. Based upon present treatment levels and once in 10 year 7 day low flows, the model indicated that in 59.0 miles of stream the D.O. concentration is below 5.0 mg/l. Fifteen of the 59.0 miles of streams are affected by a municipal discharge, 14 by industrial, and 30 miles by various other discharges (subdivisions, mobile home parks, small businesses, etc.). These distances represent 6 per cent, 6 per cent, and 12 per cent, respectively, of the total stream miles in the basin which have a discharge. (Table A-5)

E. Non-point Source Effects

Non-point pollution is a problem in Kentucky's portion of the Tennessee River basin. The major non-point sources of pollution in the basin are summarized below:

1. Land Use: Soil erosion from 145.0 sq. mi. (15% of basin area) of farm land is considered excessive by US-SCS. Logging operations, burning, and grazing in 44 sq. mi. (5% of basin area) of forest land has resulted in severe soil erosion in the area.

2. Animal Wastes: All agricultural feedlots in Kentucky have a capacity of less than 1,000 animal units and no NPDES permits have been issued in Kentucky for feedlots. Kentucky has developed a manure lagoon disposal system in cooperation with the USDA-SCS which is currently under study and is used by some small feedlots. These lagoon systems have been employed in the Mississippi River Basin and protected water quality when properly operated.

3. Urban Run-off: Surface runoff from the city of Murray can have an effect on stream water quality. Without data on the effect, which is probably rather minor, the quantitation will need special investigation as part of water quality management.

F. Water Uses

Surface and ground waters in the Tennessee River Basin in Kentucky are used for Public, Industrial, Fish and Wildlife, Recreation, and Agricultural Water Supply. The groundwater in this area is generally of good quality with the exception of iron. Groundwater is the source of about 90 per cent of the public water supply in the region amounting to 2.0 million gallons per day (m.g.d.).

Due to the industrial location groundwater does not play an important role for industrial water supply. The industrial use of groundwater in the basin is 3 m.g.d. Of the 45.0 m.g.d. used in the basin for industrial purposes, about 42.0 m.g.d. (93 per cent) is supplied by the main stem of the Tennessee River.

Kentucky Lake and Barkley Lake with the Land Between the Lakes serve as a recreational area of great diversity. The water quality supports game fish, plants, and wildlife and the size of the area accommodates a large number of people. Millions of people use Kentucky Lake for various recreational activities, and the Tennessee River is valuable for commercial fishing and mussel shells.

Water in the basin is used in the agricultural industry primarily for livestock watering with a small amount used for irrigation. There is no known area in the basin where water is restricted from use for agricultural needs.

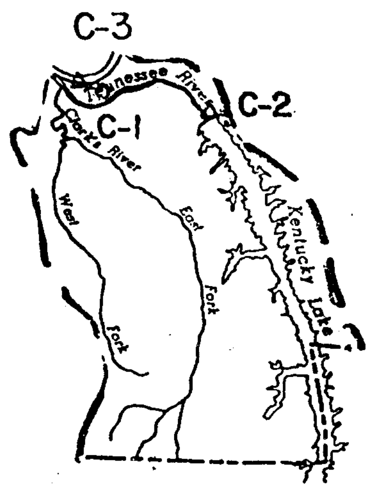
G. Water Quality Changes

The potential for water quality change, particularly within a mixing zone,occurs as a result of large scale industrial development located at Calvert City. Particular attention must be paid to compliance monitoring and special surveys to prevent any water quality deterioration from this complex. The water quality changes which can be expected are for the better as waste treatment facilities are upgraded to maintain dissolved oxygen levels above 5 mg/l. Because of the high level of recreation use of Kentucky Lake particular attention must be paid to probable waste disposal at camp sites, recreation developments, State parks, and other facilities to prevent spot contamination of the lake. This control is being exercised by revising of plans and specifications for water disposal systems and the further restrictions imposed in the location of septic tanks ar drain fields in relationship to the elevation of Kentucky Lake.

III. Summary

The water quality in the main stem of the Tennessee River in Kentucky is excellent. Sampling and testing in the Clarks River basin have not been sufficient to make a definite conclusion as to the water quality throughout the basin. To maintain the high water quality in the basin requires attention to industrial waste effects at Calvert City, upgrading of municipal sewage treatment plants and other small sewage treatment systems.

Treated wastes discharged from municipal, independent, and industrial sources effect the quality of the basin's streams. The need to upgrade or eliminate waste sources is being determined in the basin planning process. Another aspect of this problem is the need for improved operation and maintenance of waste treatment facilities through a program of operator licensing and education. Kentucky has instituted such programs.



o U.S.G.S.

△ Kentucky Division of Water

TENNESSEE RIVER

10 0 10 20 30 40

GRAPHIC SCALE IN MILES

Base Data: U. S. Geological Survey

STATION KEY

C-1 TENNESSEE RIVER NEAR HWY 60 NE

C-2 TENNESSEE RIVER NEAR PADUCAH WPI

C-3 TENNESSEE RIVER AT KENTUCKY STATE LINE

Table C-1
Population in the Tennessee River Basin by County

County	Area (sq. mi.)	1970 Pop.	Area in Basin (sq. mi.)	Pop. in Basin
Calloway	384	27,692	367	27,082
Graves	560	30,939	102	3,494
Livingston	311	7,596	39	868
Lyon	216	5,562	35	509
Marshall	303	20,381	303	20,381
McCracken	249	58,281	48	15,000 est.
Trigg	408	8,620	74	1,078
			968	68,412

Note: The information in this table was taken from the 1970 Census as reported in the Rand McNally.

Table C-2

Water Withdrawal in the Tennessee River Basin

County-City-Withdrawer	River/Lake	SW	GW	Public (mgd)	Industrial (mgd)
Calloway					
Dexter-Almo Hts. W. Dist.			x	.023	
Hamlin-G. H. Wesson			x		.146
Hazel Mncp. W. W.			x	.022	
Lynn Grove Mncp. W. W.			x	.004	
Murray Mncp. W. W.			x	1.0	.73
Lynhurst Resort, Inc.			x	.026	
Murray Bait Co.			x		.24
Murray State U.			x		.69
Graves					
Symsonia W. Dist.			x	.025	.001
Livingston					
Grand Rivers Mncp. W. W.	Ky. Lake	x		.06	
Lake City W. Dist.	Ky. Lake	x		.032	
McCracken					
Reidland W. Dist			x	.15	.008
Marshall					
Benton Mncp. Water and Sewer System			x	.32	.007
N. Marshall Co W. Dist.			x	.19	.021
Jonathan Creek Water Ass.	Ky. Lake	x		.14	
Calvert City Mncp. W. W.			x	.45	
Airco Alloys and Carbide	Tenn. R.	x			12.0
American Aniline & Extract			x		.19
B. F. Goodrich Chem. Co.	Tenn. R.	x			4.0
GAF Corp.			x		1.3
Pennwalt Chem. Corp.	Tenn. R.	x			25.0
Pittsburg Metallurgical	Tenn. R.	x			1.3
Gilbertsville Mncp. W. W.			x	.03	
Hardin Mncp. W. W.			x	.05	
Ky. Dam Village S. P.			x	.19	
Ky. Lake S. P.			x	.068	

*Mncp. W. W. - Municipal Water Works
W. Dist. - Water District
S. P. - State Park

NOTE: Data obtained from Kentucky Department for Natural Resources and Environmental Protection, Division of Water Resources.

Table C-3

City Population and Facility Grant Status in the Tennessee River Basin in Kentucky

County	City	Population	Project Type	Comments
Calloway	Murray- (Hazel)	13,700 424	1	Active
Graves	Symsonia	500	1	Active (EDA Grant)
Livingston				
Lyon				
McCracken	(Reidland W. D.)	875	1	Active
	(Woodlawn W. D.)		1	Active
Marshall	Benton- (Hardin)	3,652 522	1	Active
	Calvert City	2,104	1	Active
Trigg				

NOTE: Project type is related to the grant process step applied for or active for each municipality. Step 1 is the preliminary studies (201 Facilities Plan) required before design of the facilities. Step 2 is the design phase of the project, and Step 3 is the construction of facilities for the collection and treatment of wastewaters.

The comments relate to the status of the grant. Active indicates the project is funded and underway. Pending indicates that application for a grant has been made and is pending approval. No sewers indicates that the municipality does not presently have a comprehensive sewer system. Sewers/STP indicates the municipality is now served by sewers and treatment facilities.

The source of this information was the 1970 U. S. Census and the FY 77 construction grants list for Kentucky.

Table C-4

Water Quality Date for Tennessee River Basin

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
STORET #00400	pH (specific units Ky. Std. 6 LT pH LT 9						
Tennessee R. Hwy 60 NE	76/01/15	76/12/10	7.3	8.4	6.2	11	.726
USGS 03609750	73/11/26	76/12/10	7.2	8.6	6.2	29	.659
STORET #00095	Conductivity Micromhos Ky. Std. 800 Micro Mhos Max.						
Tennessee R. Hwy 60 NE	76/01/15	76/12/10	158.7	170.0	135.0	12	3.264
USGS 03609750	73/11/26	76/12/10	154.4	190.0	120.0	38	16.838
STORET #70300	Residue mg/l Ky. Std. 500 mg/l Max.						
Tennessee R. Hwy 60 NE	76/01/15	76/10/20	92.2	105.0	78.0	4	5.893
USGS 03609750	73/11/26	76/10/20	90.0	115.0	66.0	26	14.315
STORET #00410	Alkalinity mg/l No Standard						
Tennessee R. Hwy 60 NE	76/01/15	76/10/20	49.8	54.0	40.0	4	6.551
USGS 03609750	73/11/26	76/10/20	52.2	62.0	40.0	26	5.727
STORET #00900	Hardness mg/l 0-60 soft tl-120 moderately hard, 180 very hard						
Tennessee Hwy 60 NE	76/01/15	76/10/20	61.5	70.0	55.0	4	6.245
USGS 03609750	73/11/26	76/10/20	62.0	78.0	48.0	26	7.057
STORET #00930	Sodium mg/l No Standards						
Tennessee R. Hwy 60 NE	76/01/15	76/10/20	5.5	7.1	4.6	4	1.161
USGS 03609750	73/11/26	76/10/20	4.8	9.2	2.3	26	1.664
STORET #00935	Potassium mg/l No Standard						
Tennessee R. Hwy 60 NE	76/01/15	76/10/20	1.4	1.6	1.3	6	.104
USGS 03609750	73/11/26	76/10/20	1.5	3.2	1.0	28	.395
STORET #00940	Chloride mg/l proposed EPA Standard 250 mg/l						
Tennessee R. Hwy 60 NE	76/01/15	76/10/20	6.6	7.3	6.1	4	.512
USGS 03609750	73/11/26	76/10/20	5.5	8.3	2.4	26	1.537
STORET #00945	Sulfate mg/l proposed EPA Standard 250 mg/l						
Tennessee R. Hwy 60 NE	76/01/15	76/10/20	12.3	13.0	11.0	4	.957
USGS 03609750	73/11/26	76/10/20	11.3	15.0	7.8	26	1.913

Table C-4
Continued

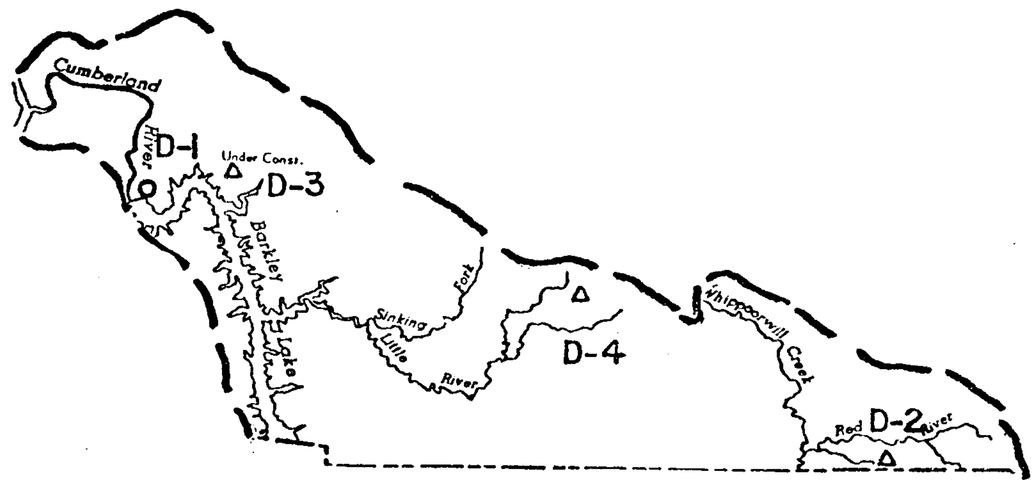
Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
STORET #00950	Flouride mg/l Ky. Std. 1.0 mg/l						
Tennessee R. Hwy 60 NE	76/01/15	76/10/20	.150	.2	0.1	4	.057
USGS 03609750	73/11/26	76/10/20	.184	.5	0.0	26	.108
STORET #00915	Calcium mg/l No Standard						
Tennessee R Hwy 60 NE	76/01/15	76/10/20	19.5	23.0	18.0	4	2.380
USGS 03609750	73/11/26	76/10/20	19.3	25.0	15.0	26	2.153
STORET #00925	Magnesium mg/l No Standard						
Tennessee R. Hwy 60 NE	76/01/15	76/10/20	3.1	3.6	2.5	4	.469
USGS 03609750	73/11/26	76/10/20	3.3	5.2	2.4	26	.670
STORET #01025	Cadmium Micorgrams per liter ug/l Ky. Std. 100 ug/l						
Tennessee R. Hwy 60 NE	76/01/15	76/10/20	1.5	6.0	0.0	4	3.000
USGS 03609750	73/12/18	76/10/20	1.07	6.0	0.0	13	1.705
STORET #01030	Chromium ug/l Proposed EPA Std. 50 ug/l						
Tennessee R. Hwy 60 NE	76/01/15	76/10/20	1.0	4.0	0.0	4	2.0
USGS 03609750	74/03/13	76/10/20	0.5	4.0	0.0	12	1.2
STORET #01049	Lead ug/l Ky. Std. 50 ug/l						
Tennessee R. Hwy 60 NE	76/01/15	76/10/20	16.5	49.0	0.0	4	23.572
USGS 03609750	73/12/18	76/10/20	6.8	49.9	0.0	13	13.779
STORET #01000	Arsenic ug/l Ky. Std. 50 ug/l						
Tennessee R. Hwy 60 NE	76/01/15	76/10/20	.25	1.0	0.0	4	0.5
USGS 03609750	73/12/18	76/10/20	.53	1.0	0.0	13	.518
STORET #31503	Total coliform colonies per 100 ml, Ky Std 1000 per 100 ml						
Tennessee R. Paducah WPI	76/01/13	76/12/08	653	1950	0.0	12	
Total Coliform	74/04/16	75/12/15	297	1190	0.0	22	

Table C-5

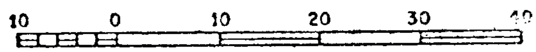
Organic Loads Affecting Streams in the Tennessee River Basin

Length of streams to which treated organic loads are discharged		248
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow		59
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow due to	Municipal Discharges	15
	Industrial Discharges	14
	Other Discharges	30

Note: This information is from the wasteload allocation for Kentucky and is an output from the 303e river basin planning effort. The values indicate the stream miles in which the dissolved oxygen is predicted to be less than 5 mg/l when the stream flow is less than the once in ten year seven day (Q10-7) low flow.



LOWER CUMBERLAND RIVER



GRAPHIC SCALE IN MILES

Base Data: U. S. Geological Survey

LOWER CUMBERLAND BASIN

The first section of this report will deal with the general description of the basin. The second section will go into a discussion of the water quality in the basin, its causes and effects.

I. Basin Description

A. Geography

The Lower Cumberland River is located in Western Kentucky. The confluence with the Ohio River is at the town of Smithland, Kentucky. The Kentucky-Tennessee border is at mile point 74.7 on the Cumberland River. The area of this portion of the drainage basin in Kentucky is 1,900 sq. mi. of a total drainage basin area of 17,900 sq. mi. This basin contains all or portions of 9 Kentucky counties which are listed in Table D-1. There are two major sub-basins in this region, namely the Little River with 601 sq. mi. and the Red River with a total drainage basin area of 1,460 sq. mi. of which 688 are in Kentucky. At mile point 30.3 Barkley Lock and Dam forms Barkley Lake with a pool 118 miles in length, 44 miles of which are in Kentucky.

B. Topography

The topography of the Lower Cumberland River Basin is composed of gently rolling plains and "Karst" areas. Karst topography is characterized by sinkholes, underground solution channels and caves.

Stream slopes affect the rate at which dissolved oxygen levels are replenished. Stream slopes of 2 feet per mile and less have low reaeration rates, slopes of 2 feet per mile to 6 feet per mile have moderate reaeration rates, and slopes of 6 feet per mile and greater have higher reaeration rates. The main stem of the Cumberland River below Barkley Lake has a slope of 5.7 feet per mile to the point where Livingston Creek enters the Cumberland River. The slope is very low from Livingston Creek to the Ohio River. Of the major tributaries listed in Table D-2, three (based on slope only) have low reaeration rates, five have moderate reaeration rates and fourteen have high reaeration rates. Many of the tributary streams have a low slope near the confluence with the Cumberland River which can present special problems in maintaining dissolved oxygen levels of 5 milligrams per liter (mg/l).

In the Lower Cumberland Basin stream elevations in the headwaters rise to 600 feet above mean sea level (m.s.l.). The elevation is 302 feet at the Ohio River.

C. Geology

The principal geological feature of this basin contributing to surface water quality is the limestone parent material. Limestone underlies the entire basin with the exception of the Livingston County portion which is part of a fluoropsar district along the Ohio River. The limestone base parent material contributes to the hardness of the groundwater which ultimately contributes to the hardness of the surface water.

The limestone parent material does not provide high yielding aquifers. Groundwater reserves are moderate to low throughout the basin. In approximately 80 per cent of the basin, wells produce 50 g.p.m. or less and the remaining wells produce 50-500 g.p.m.

D. Hydrology

The Cumberland River is a highly developed river system with a series of locks and dams which permit navigation upstream for 380 miles. The river above this point is further regulated by dams for multiple purpose control, principally flood, recreation and power. There are three lakes in this portion of the basin with surface areas of over 100 acres: Lake Barkley with 57,900 acres, Lake Morris with 170 acres and Lake Boxley with 166 acres. Lake Barkley is regulated for navigation, flood, power, recreation and fish and wildlife purposes. The Kentucky-

Barkley canal at mile point 32.7 permits navigation between Barkley and Kentucky Lake and provides for flow regulator.

The USGS flow gauging stations data at Little River at Cadiz in Trigg County and the Cumberland River at Grand Rivers in Lyon County is tabulated below. The Little River enters Barkley lake 59 miles from the Ohio River and drains an area of 244 sq. mi. The gauging station at Grand Rivers measures the flow through Barkley Lake and drains an area of 17,600 sq. mi. Occasionally the flow from Barkley Dam is stopped for operating and maintenance of the facilities for periods which do not exceed seven days.

E. Population

The population of the Lower Cumberland Basin in Kentucky is predominately rural. Small communities are located along the main stem and many of the smaller tributaries. The county with the largest population is Christian County with 56,224 persons. The city of Hopkinsville in Christian County has a population of 21,409. The other municipality with a population over 2,000 is Princeton with 6,292 population. The total basin population is 92,380 of which 45 per cent is urban and 55 per cent is rural.

TABLE D-8

SURFACE WATER RECORDS FOR THE LOWER CUMBERLAND RIVER BASIN

STATION	PERIOD OF RECORD	DRAINAGE AREA	AVERAGE FLOW	MAXIMUM FLOW	MINIMUM FLOW	7-day/10-yr. LOW FLOW
Little River at Cadiz	36 yr.	244 sq.mi.	343 cfs, 1.4cfs*/sq.mi.	19,400 cfs, 80 cfs/sq.mi.	1 cfs, 0.0cfs/sq.mi.	0.06 cfs
	wtr/yr 1976		313 cfs, 1.3cfs/sq.mi.	6,600 cfs, 27 cfs/sq.mi.	20 cfs, 0.1cfs/sq.mi.	
Cumberland River at Grand Rivers	25 yr.**	17,598 sq.mi.	27,510 cfs, 1.6cfs/sq.mi.	201,000 cfs, 11 cfs/sq.mi.		620 cfs
	11 yr.**		39,210 cfs, 2.2cfs/sq.mi.	209,000 cfs, 12 cfs/sq.mi.		
	wtr/yr 1976		42,830 cfs, 2.4cfs/sq.mi.	116,000 cfs, 6.6cfs/sq.mi.	4,960 cfs, 0.3cfs/sq.mi.	

* Cubic feet per second

** 25 Years (1940-1965), prior to opening of Barkley-Kentucky Canal.
10 Years (1965-1975), since opening of Barkley-Kentucky Canal.

NOTE: Data is taken from "Surface Water Records in Kentucky" by the United States Geological Survey. The 7-day/10-yr. low flow was taken from the waste load allocation produced as a component of the 303e River Basin Continuing Planning Process.

II. Basin Water Quality

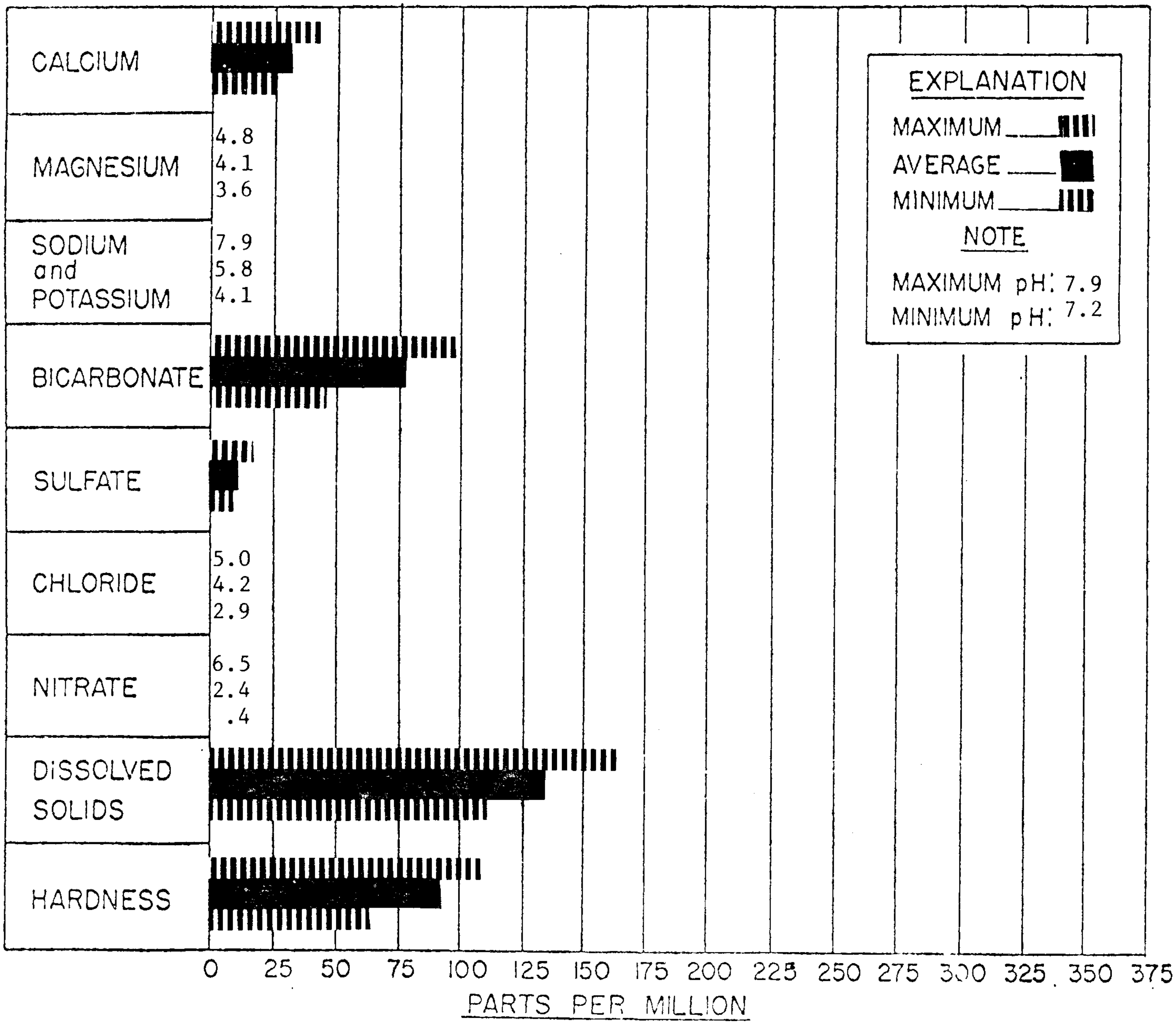
A. Description of Sampling Stations

Two sampling stations were chosen to characterize the water quality for the Lower Cumberland River Basin. The USGS gauging station was on the Cumberland River at Grand Rivers below Barkley Lake. The total drainage area above this station 17,598 square miles. The Kentucky Water Quality station used was the Princeton water plant intake on Barkley Lake in Caldwell County.

B. General Chemical Water Quality

The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The chemical characteristics of a stream when viewed over a long period of time is primarily from surface water. The type of rock formation and soils which the surface water contacts causes this predominate chemical characteristic. The contribution of groundwater, which is generally higher in dissolved solids than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky is of moderate hardness caused by calcium and magnesium salts. The influence of mining activities is clearly indicated when the sulfate content increases to a higher level than the bicarbonate content, and the pH is on the acid side, below pH 5.5.

Two stations were selected to characterize the general chemical water quality in the Lower Cumberland River Basin. The data for the stations selected was retrieved in a manner to delete extreme values not characteristic of the basin water quality. The water



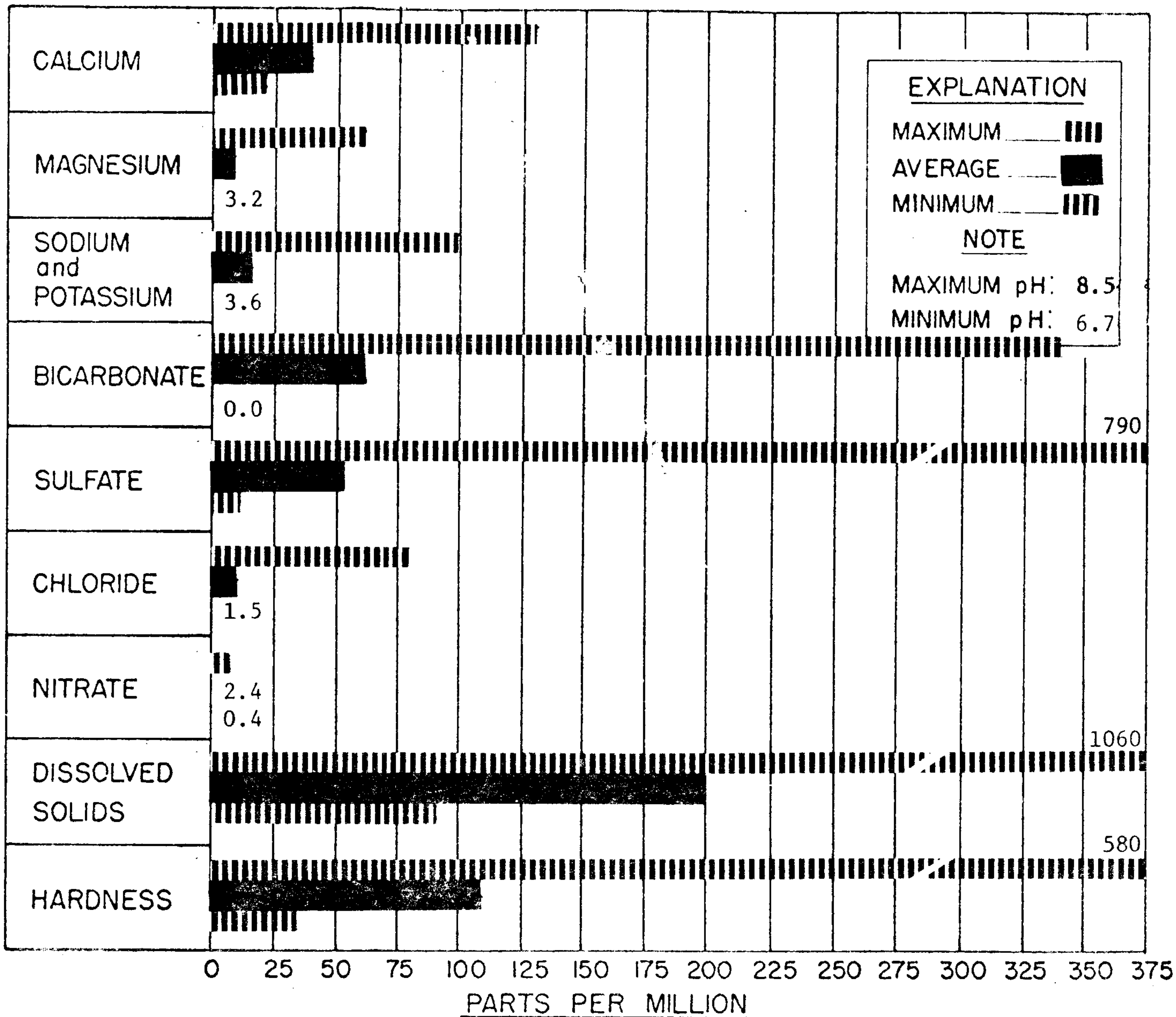
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE D-1

Lower Cumberland River

Grand Rivers

11-73 to 12-74



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE D-2

Lower Cumberland

Grand Rivers

8-66 to 12-74

quality in the Cumberland River Basin is reflective of the same water quality as that in the Tennessee River below Kentucky Dam since the canal permits free interchange of water between the two lakes.

C. Trace elements (under 5 mg/l) are separated from the general chemical background of this report because of their influence on human health. Generally, these materials are "heavy" metals which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State and Federal Water Quality Standards.

All trace chemicals measured in the Lower Cumberland Basin with the exception of lead and chronimum were within Kentucky-Federal Water Quality Standards. Average values for all trace chemicals including lead and chronium were within Kentucky-Federal guidelines. The value for lead exceeded the limit one time; the level being .07 mg/l as compared with the standard of .05 mg/l. The value for chromium is for total chromium rather that the hexa-valent chromium and the level of exceedence at .11 mg/l is not sufficient to warrent further investigation.

D. Waste Load Affect on Water Quality

Biochemically degradable wastes impose a load on the dissolved oxygen recourses of a stream. Such waste loads are considered to have an effect on stream quality when they cause the dissolved oxygen (D.O.) levels to drop below Kentucky Water Quality Standards of 5 mg/l.

Using a model developed in conjunction with the River Basin Planning Process, 360 miles of streams with waste loads in the Lower Cumberland Basin were studied. Of this total, 17.3 per cent or 62.2 miles were shown to have loads in 1975 which would cause the D.O. levels to be below 5 mg/l at a low flow occurrence of once in 10 years for 7 days.

The type of waste and the distance affected in this basin where D.O. levels are less than 5 mg/l, are municipal discharges 40 miles or 11% of the total and other discharges (hospitals, mobile home parks, and schools) 22 miles or 6 %.

E. Non-Point Source Effects

The major non-point pollutants from the portion of Kentucky that drains directly into the Cumberland River are sediment, animal waste, and solid waste.

Sources of excessive sediment areas were identified in an inventory of critically eroding areas prepared in 1974 by the USDA Soil Conservation Service. About 122 square miles (sq. mi.) of cropland were judged to have excessive erosion rates. An estimated 44 sq. mi. of forest land have excessive erosion as a result of logging operations, burning, and grazing.

F. Water Uses in the Basin

Most of the surface water withdrawn in this basin is for public uses. Of the total surface water used, 4.8 million gallons per day were used for municipal purposes. Industrial uses of surface water amounts to 563,000 gallons per day. A complete breakdown of water uses, both surface and groundwater, by industries and municipalities is shown in Table D-8.

At the present time, agricultural uses of surface water supplies is primarily livestock watering. It can be expected that use of surface waters for irrigation will increase in the future.

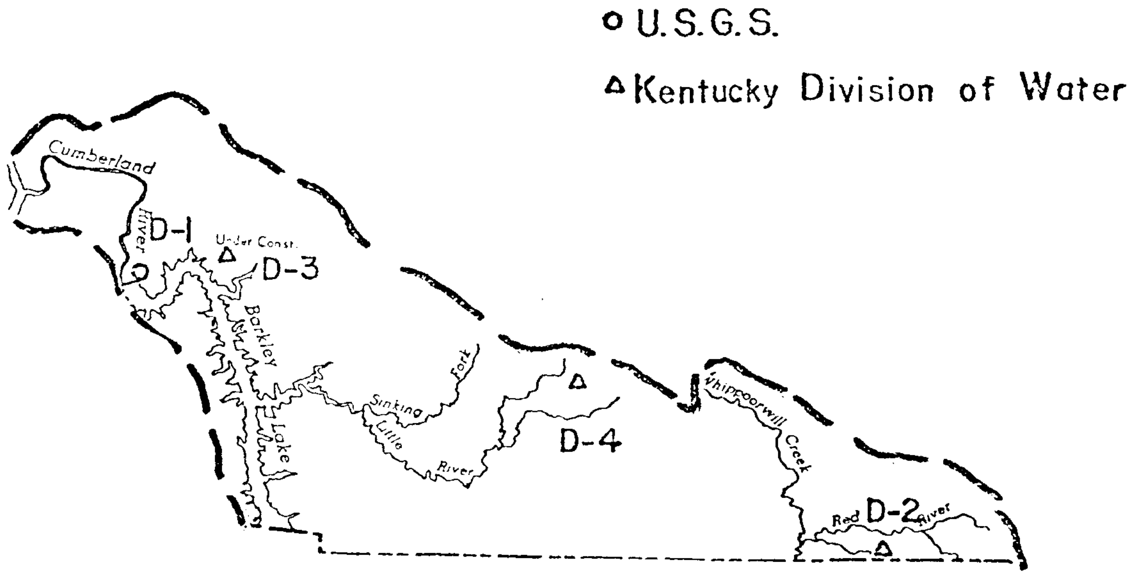
Barkley Lake in the Lower Cumberland River Basin and Kentucky Lake in the Tennessee River Basin provide a great variety of water related activities. Barkley Lake is the largest lake in the Cumberland River system. Lake Barkley State Resort Park at Cadiz, Kentucky and the Land-Between-the-Lakes provides for both water and non-water recreational activities year round.

G. Water Quality Changes

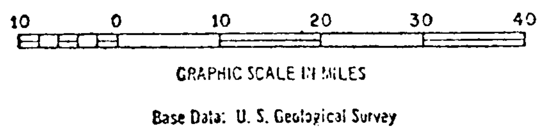
The water quality in the Lower Cumberland River Basin in the main stem and Barkley Lake is of uniform excellent quality. This conclusion is derived from a few values from STORET data which were known to be from the main stem of the Cumberland River and from the information presented in the Tennessee River Basin Report. Both of these rivers are interconnected by canal and, therefore, share similar water quality. As far as tributary streams to the Cumberland River, the changes expected will be for upgrading waste treatment facilities with an accompanying improvement for water quality and better control of land use practices, particularly agricultural uses to minimize the effects of soil erosion. The Soil Conservation Service has identified a particular area of concern and cooperative efforts of the Division of Water of the Department for Natural Resources and Environmental Protection with the Soil Conservation Service will produce the necessary control to minimize the effect of sedimentation in the tributary streams.

III. Summary

The unique features of the Lower Cumberland Basin include a large recreation area which is associated with Barkley Lake, Kentucky Lake and the Land-Between-the-Lakes. This recreational potential must be given high priority for the protection of localized contamination from waste facilities and for control of sediment loads to prevent siltation of embayment areas. The other feature which contributes to water quality changes is the "Karst" topography which increases hardness in tributaries and makes groundwater from solution channels and pools within caverns difficult to protect from bacteriological contamination. In these areas groundwater is of questionable bacteriological quality and extension of rural water supplies providing treated water should be encouraged.



LOWER CUMBERLAND RIVER



STATION KEY

D-1 CUMBERLAND RIVER AT GRAND RIVERS

D-2 RED RIVER AT ADAIRVILLE WPI

D-3 LAKE BARKLEY AT EDDYVILLE WPI

D-4 NORTH FORK LITTLE RIVER AT HOPKINSVILLE

Table D-1

Drainage Areas in the Lower Cumberland Basin

AREA DATA

COUNTY	TOTAL AREA	PERCENT AREA IN BASIN	AREA IN BASIN IN SQUARE MILES
Caldwell	357	44.7	160
Christian	726	63.6	462
Crittenden	365	21.8	80
Livingston	317	37.8	120
Logan	563	39.4	222
Lyon	254	83.8	213
Simpson	239	39.9	95
Todd	376	64.3	242
Trigg	457	83.1	380
		Total,	1,933

Source: This information was taken from Kentucky Water Quality Standards for Interstate Waters, Kentucky Water Pollution Control Commission, June, 1967.

Table D-2

Slope and Elevations of Streams in the Lower Cumberland Basin

Slopes

CREEK	AVERAGE (feet/mile)	ELEVATIONS Head	Mouth
South Fork Red River	5.28	530	468
Elk Fork	6.64	650	470
Big West Fork	6.44	600	400
Red River	4.4	600	450
South Fork Little River	7.58	660	475
Caney Creek	26.18	448	359
Little River	2.39	550	359
Dry Creek	15.17	450	362
Eddy Creek	4.15	450	359
Hammond Creek	27.9	490	359
Caldwell Springs	20.0	373	329
Crab Creek	17.87	428	319
Panther Creek	20.55	420	307
Livingston Creek	2.37	329	302
Cox Spring Branch	35.7	426	355
Sandy Creek	5.31	319	302
Clear Branch	22.0	330	319
Knob Creek	21.3	393	359
Lick Creek	4.4	370	359
Blue Spring Creek	0	359	359
Montgomery Creek	15	620	461
McCormick Creek	19.35	332	302

Note: This information is from the waste load allocation for Kentucky and is an output from the 303e River Basin Planning Effort.

Table D-3

Lakes in the Lower Cumberland River Basin

LAKES	VOLUME (Acre-Feet)	AREA(Acres)
Morris - North Fork Little River	1740	170.0
Boxley - North Fork Little River	2006	166.0
Blythe - North Fork Little River	1313	89.0
Barkley - Cumberland River	259,000	57,920

Source: Kentucky Department for Natural Resources and Environmental Protection Division of Water Resources.

Table D-4

Population in the Lower Cumberland Basin by County

COUNTY	TOTAL POPULATION IN COUNTY IN 1970 ***	POPULATION IN BASIN*
Caldwell	13179	9619
Christian	56224	43378
Crittenden	8493	1196
Livingston	7596	3762
Logan	21793	5919
Lyon	5562	5055
Simpson	13054	2594
Todd	10823	8140
Trigg	8620	7499
		87162

* Population in basin is found by taking rural population evenly distributed across the county and multiplying by percentage of area of the county in the basin. City populations are then added to this figure.

*** 1970 U.S. Census Data from Rand McNally Standard Reference Map and Guide of Kentucky.

Table D-5

City Population and Facility Grant Status in the Lower Cumberland River Basin in Kentucky

City	County	Population	Project Type	Comments
Caldwell	Princeton	6,292	1	Active
	Fredonia	450	1	Pending
Christian	Hopkinsville	21,400	1	Active
	Pembroke	634	None	Sewers/STP
Crittenden				
Livingston	Smithland-	514	1	Active
	(Ledbetter)	15	1	Active
	Salem	480	1	Active
	Grand Rivers (Lake City W. D.)	438	1	Active
Logan	Adairville	973	1	Active
Lyon	Eddyville	1,981	None	Sewers/STP
	(Kuttawa)	453	None	Sewers/STP
Simpson				
Todd	Elkton	1,612	1	Active
	Guthrie	1,200	1	Active
	Trenton	496	None	Sewers/STP

NOTE: Project type is related to the grant process step applied for or active for each municipality. Step 1 is the preliminary studies (201 Facilities Plan) required before design of the facilities. Step 2 is the design phase of the project, and Step 3 is the construction of facilities for the collection and treatment of wastewaters.

The comments relate to the status of the grant. Active indicates the project is funded and underway. Pending indicates that application for a grant has been made and is pending approval. No sewers indicates that the municipality does not presently have a comprehensive sewer system. Sewers/STP indicates the municipality is now served by sewers and treatment facilities.

The source of this information was the 1970 U. S. Census and the FY 77 construction grants list for Kentucky.

Table D-6

Water Uses in Lower Cumberland River Basin

	Total (gpd)	Well (gpd)	Surface (gpd)
Municipal	5,210,000	395,000	4,820,000
Industrial	1,095,000	532,000	563,000

Source: Kentucky Department for Natural Resources and Environmental Protection, Division of Water Resources.

Table D- 7

Organic Loads Affecting Streams in the Lower Cumberland Basin

Length of streams to which treated organic loads are discharged		360 miles
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow		62 miles
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow due to	Municipal Discharges	40 miles
	Other Discharges	22 miles

Note: This information is from the waste load allocation for Kentucky and is an output from the 303e River Basin Planning effort. The values indicated the stream miles in which the dissolved oxygen is predicted to be less than 5 mg/l when the stream flow is less than the once in ten year seven day (Q 10-7) low flow.

Table D-8

Water Quality Data for Lower Cumberland Basin

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
STORET #00400	pH Specific Units Kentucky Standard 6 LT pH LT 9						
Cumberland River-	76/01/13	76/12/08	7.2	7.9	6.3	11	.534
Grand River	70/02/25	75/12/09	7.2	7.9	6.4	30	.394
U.S.G.S. 03438220	66/01/19	76/12/08	7.3	8.5	6.3	55	.464
STORET # 00095	Conductivity Micro mho, Ky. Std. 800 Micro mhos						
Cumberland River-	76/01/13	76/12/08	195.8	230.0	180.0	12	15.643
Grand River	70/01/28	75/12/09	183.9	229.0	138.0	42	21.058
U.S.G.S. #03438220	66/01/19	76/12/08	189.2	239.0	138.0	74	21.638
STORET #70300	Dissolved Solids mg/l, Ky. Std. 500 mg/l						
Cumberland River-	76/01/13	76/08/06	110.0	126.0	96.0	3	15.100
Grand River	70/02/25	75/10/21	111.8	162.0	86.0	33	18.035
U.S.G.S. #03438220	66/01/19	76/08/06	113.8	162.0	86.0	50	17.604
STORET #00410	Alkalinity mg/l No Standard						
Cumberland River-	76/01/13	76/10/18	72.0	84.0	63.0	4	9.487
Grand River	70/02/25	75/10/21	68.4	96.0	53.0	33	10.170
U.S.G.S. #03438220	67/11/30	76/10/18	68.9	96.0	53.0	48	9.744
STORET #00900	Hardness mg/l, 0-60 Soft, 61-120 MOD, Hard, 121-180 Hard, 180 + Very Hard						
Cumberland River-	76/01/13	76/08/06	94.3	110.0	80.0	3	15.045
Grand River	70/02/25	75/10/21	83.4	110.0	63.0	33	11.239
U.S.G.S. #3438220	66/01/19	76/08/06	85.4	110.0	63.0	50	11.634
STORET #00935	Potassium mg/l No Standard						
Cumberland River-	76/01/13	76/08/06	1.4	1.4	1.3	4	.050
Grand River	70/02/25	75/10/21	1.4	2.4	1.1	25	.292
U.S.G.S. #03438220	66/08/08	76/08/06	1.4	2.4	1.1	32	.268
STORET #00940	Chloride mg/l Proposed E.P.A. Std. 250 mg/l						
Cumberland River-	76/01/13	76/08/06	3.2	3.9	2.4	3	.755
Grand River	70/02/25	75/10/21	3.9	13.0	1.7	33	1.925
U.S.G.S. #03438220	66/01/19	76/08/06	4.6	13.0	1.7	50	2.548

Table D-8
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
STORET #00945	Sulfate mg/l Proposed E.P.A. Std. 250 mg/l						
Cumberland River-	76/01/13	76/08/06	15.3	16.0	15.0	3	.577
Grand River	70/02/25	75/10/21	15.8	21.0	10.0	33	2.709
U.S.G.S. #03438220	66/01/19	76/08/06	16.7	24.0	10.0	50	2.914
STORET #00618	Nitrate - N mg/l, Proposed E.P.A. Std. 10 mg/l						
Cumberland River-	72/01/25	72/08/09	.780	.840	.700	3	.072
Grand River	72/01/25	72/08/09	.780	.840	.700	3	.072
U.S.G.S. #03438220							
STORET #00950	Flouride mg/l Kentucky Std. 1.0 mg/l						
Cumberland River-	76/01/13	76/08/06	.133	.200	.100	3	.058
Grand River	70/02/25	75/10/21	.171	.400	.000	28	.108
U.S.G.S. #03438220	66/01/19	76/08/06	.197	1.200	.000	35	.201
STORET #00915	Calcium mg/l No Standard						
Cumberland River-	76/01/13	76/08/06	31.0	36.0	26.0	3	5.000
Grand River	70/02/25	75/10/21	27.2	39.0	20.0	25	4.675
U.S.G.S. #03438220	66/08/08	76/08/06	27.5	39.0	20.0	31	4.625
STORET #00925	Magnesium mg/l No Standard						
Cumberland River-	76/01/13	76/08/06	3.8	4.0	3.6	3	.208
Grand River	70/02/25	75/10/21	3.9	5.1	3.1	25	.538
U.S.G.S. #03438220	66/08/08	76/08/06	3.9	5.1	3.1	31	.555
STORET #01025	Cadmium Micrograms/Liter Kentucky Std. 10ug/l						
Cumberland River-	76/01/13	76/08/06	4.7	11.0	1.0	3	5.508
Grand River	73/05/03	75/10/21	1.7	10.0	.000	11	2.832
U.S.G.S. #03438220	73/05/03	76/08/06	2.4	11.0	.000	14	3.522
STORET #01056	Manganese ug/l Proposed Kentucky Std. 50 ug/l						
Cumberland River-	76/01/13	76/08/06	3.3	10.0	.000	3	5.774
Grand River	72/01/25	75/10/21	29.4	200.0	.000	14	53.811
U.S.G.S. #03438220	72/01/25	76/08/06	24.8	200.0	.000	17	49.613

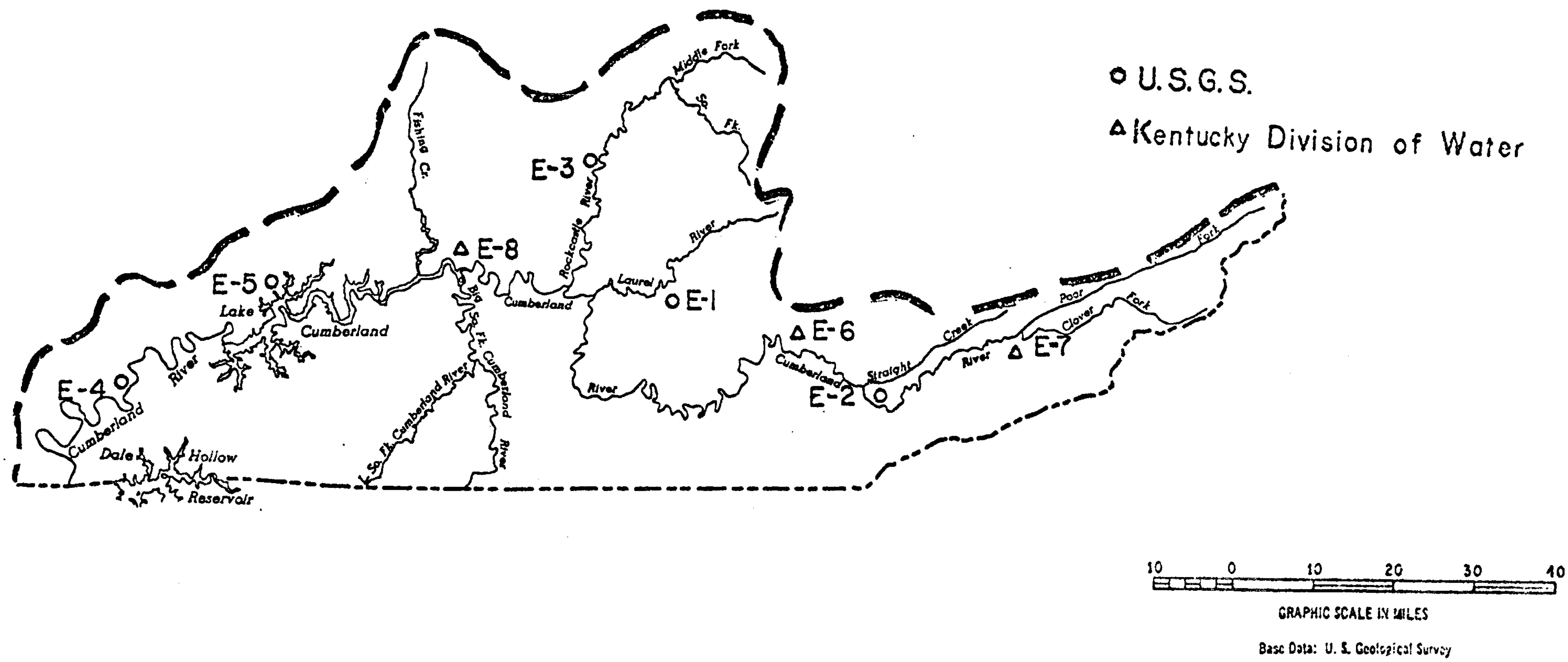
Table D-8
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
STORET #01046	Iron u g/l Proposed E.P.A. Std. 300 u g/l						
Cumberland River-	76/01/13	76/08/06	6.7	10.0	.000	3	5.774
Grand River	72/01/25	75/10/21	41.4	250.0	.000	14	66.084
U.S.G.S. #03438220	72/01/25	76/08/06	35.3	250.0	.000	17	61.147
STORET #01030	Chromium u g/l, Kentucky Std. 50 u g/l						
Cumberland River-	76/01/13	76/08/06	.667	2.0	.000	3	1.155
Grand River	73/05/03	75/10/21	.182	2.0	.000	11	.603
U.S.G.S. #03438220	73/05/03	76/08/06	.286	2.0	.000	14	.726
STORET #01049	Lead ug/l, Kentucky Std. 50 u g/l						
Cumberland River-	76/01/13	76/08/06	9.0	16.0	2.0	3	7.000
Grand River	73/05/03	75/10/21	3.9	12.0	.000	11	4.036
U.S.G.S. #03438220	73/05/03	76/08/06	5.0	16.0	.000	14	4.977
STORET #01000	Arsenic ug/l Kentucky Std. 50 u g/l						
Cumberland River-	76/01/13	76/08/06	.667	1.0	.000	3	.577
Grand River	73/05/03	75/10/21	1.2	5.0	.000	11	1.777
U.S.G.S. #03438220	73/05/03	76/08/06	1.1	5.0	.000	14	1.592
	Kentucky Standard Total Coliform 1000/100 ml						
Total Coliform	Colonies per 100 ml. STORET #31503						
Fecal Coliform	Colonies per 100 ml. STORET #31616						
Red River,	73/11/27	74/06/10	1023.8	4500.0	80.0	8	1470.670
Adairville WPI	73/11/27	74/06/10	1023.8	4500.0	80.0	8	1470.670
T. Coliform							
F. Coliform	76/01/13	76/11/02	28.6	150.0	1.0	11	43.640
	74/06/10	75/12/09	82.3	340.0	10.0	12	103.035
	74/06/10	76/11/02	56.9	340.0	1.0	23	83.307
Lake Barkley,							
Eddyville WPI							
T. Coliform							

Table D-8
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
N. Fork Little River	75/01/07	75/12/17	786	3300	4	12	
Hopkinsville	74/04/15	75/12/17	2471	12266	4	22	
T. Coliform							
F. Coliform	75/10/22	75/10/22	267	267	267	1	

UPPER CUMBERLAND RIVER



THE UPPER CUMBERLAND RIVER BASIN

The Upper Cumberland River Basin is of considerable historic significance to Kentucky. It is through Cumberland Gap near Middlesboro that Doctor Walker first came to the state in 1757. Daniel Boone also entered Kentucky from Virginia through Cumberland Gap and made his trek through most of the Lower Cumberland finally establishing settlements at Boonesboro on the Kentucky River. Much of the Upper Cumberland River Basin is relatively undisturbed with a wild river designated in the South Fork of the Cumberland River.

I. Basin Description

A. Basin Description

The Cumberland River originates at Harlan, Kentucky at the confluence of Poor Fork and Clover Fork 694 miles from its confluence with the Ohio River. The flow is generally in a westerly direction turning south below Lake Cumberland before flowing into Tennessee. The total basin drainage area in Kentucky is 5,077 sq. mi. with eight (8) sub-basins consisting of 200 sq. mi. or more.

B. Topography

The topography varies from mountainous in the upper portion or headwaters of the basin to hilly, with steep cliffs along the stream courses in the lower portion. Big Black Mountain, located in Harlan County is the highest elevation in Kentucky at 4,145 feet above sea level. The average slope of the streams in the entire basin is 14 feet per mile with the main stem above Lake Cumberland averaging approximately seven feet per mile (ft./mi.).

C. Geology

Most important of the geological features which affects water quality is the extensive coal deposits found at the upper region and throughout the majority of the entire basin. The middle portion of the basin, also, consists of high-calcium limestone deposits which lends to the hardness of the water. Petroleum producing areas and refineries are found in the lower portion of the basin and always possess the potential for oil spills or leaks. These are rare, but have a tremendous shock affect when they occur.

D. Hydrology

The average flow of the main stem of the Cumberland River in Kentucky is 5,790 cubic feet per second with an average yield of 1.67 cubic feet per square mile (See Table E-4). There exist ten (10) major lakes in the basin all possessing flood control capabilities and comprising a total surface area of 102,315 acres. Three of these lakes are Corps of Engineers' projects - Lake Cumberland, Laurel River and Dale Hollow Lake - with total surface area of 100,580 acres. Lake Cumberland is the largest of the lakes with an area of 63,530 acres and is used for power, recreation, and flood control purposes.

E. Population

Population in the basin can best be described as scattered. The total population in the basin is approximately 260,000 people based on 1970 census. The majority of the population is rural. The only two cities greater than 10,000 people are Middlesboro with 11,700 and Somerset with 10,500 (1970 census). Of the entire basin population, 25 per cent reside in Harlan and Bell counties which are located near the headwaters of the basin, and 77 per cent reside in the portion above Lake Cumberland. The portion of the population in headwaters is due to coal mining.

TABLE E-4

SURFACE WATER RECORDS FOR THE UPPER CUMBERLAND RIVER BASIN

STATION	PERIOD OF RECORD	DRAINAGE AREA	AVERAGE FLOW	MAXIMUM FLOW	MINIMUM FLOW	7-day/10-yr. LOW FLOW
Cumberland River near Rowena**	37 yr.	5,790 sq.mi.	9,128 cfs, 1.6cfs* / sq.mi.	162,000 cfs, 28 cfs / sq.mi.	0 cfs	93 cfs
	wtr/yr 1976		9,245 cfs, 1.6cfs / sq.mi.	29,200cfs, 5 cfs / sq.mi.	100 cfs, 0.0cfs / sq.mi.	
Cumberland River at Cumberland Falls	66 yr.	1,977 sq.mi.	3,199 cfs. 1.6cfs / sq.mi.	59,600 cfs, 30 cfs / sq.mi.	4 cfs, 0.0cfs / sq.mi.	26 cfs
	wtr/yr 1976		2,895 cfs, 1.5cfs / sq.mi.	27,400 cfs, 14 cfs / sq.mi.	120 cfs, 0.1cfs / sq.mi.	
Cumberland River near Harlan	36 yr.	374 sq.mi.	689 cfs, 1.8cfs / sq.mi.	43,200 cfs, 116cfs / sq.mi.	3 cfs, 0.0cfs / sq.mi.	20 cfs
	wtr/yr 1976		559 cfs, 1.5cfs / sq.mi.	17,600 cfs, 47 cfs / sq.mi.	17 cfs, 0.05 cfs / sq.mi.	

* Cubic feet per second

** Flow regulated by Lake Cumberland beginning March 1950.

NOTE: Data is taken from "Surface Water Records in Kentucky" by the United States Geological Survey. The 7-day/10-yr. low flow was taken from the waste load allocation produced as a component of the 303e River Basin Continuing Planning Process.

II. Basin Water Quality

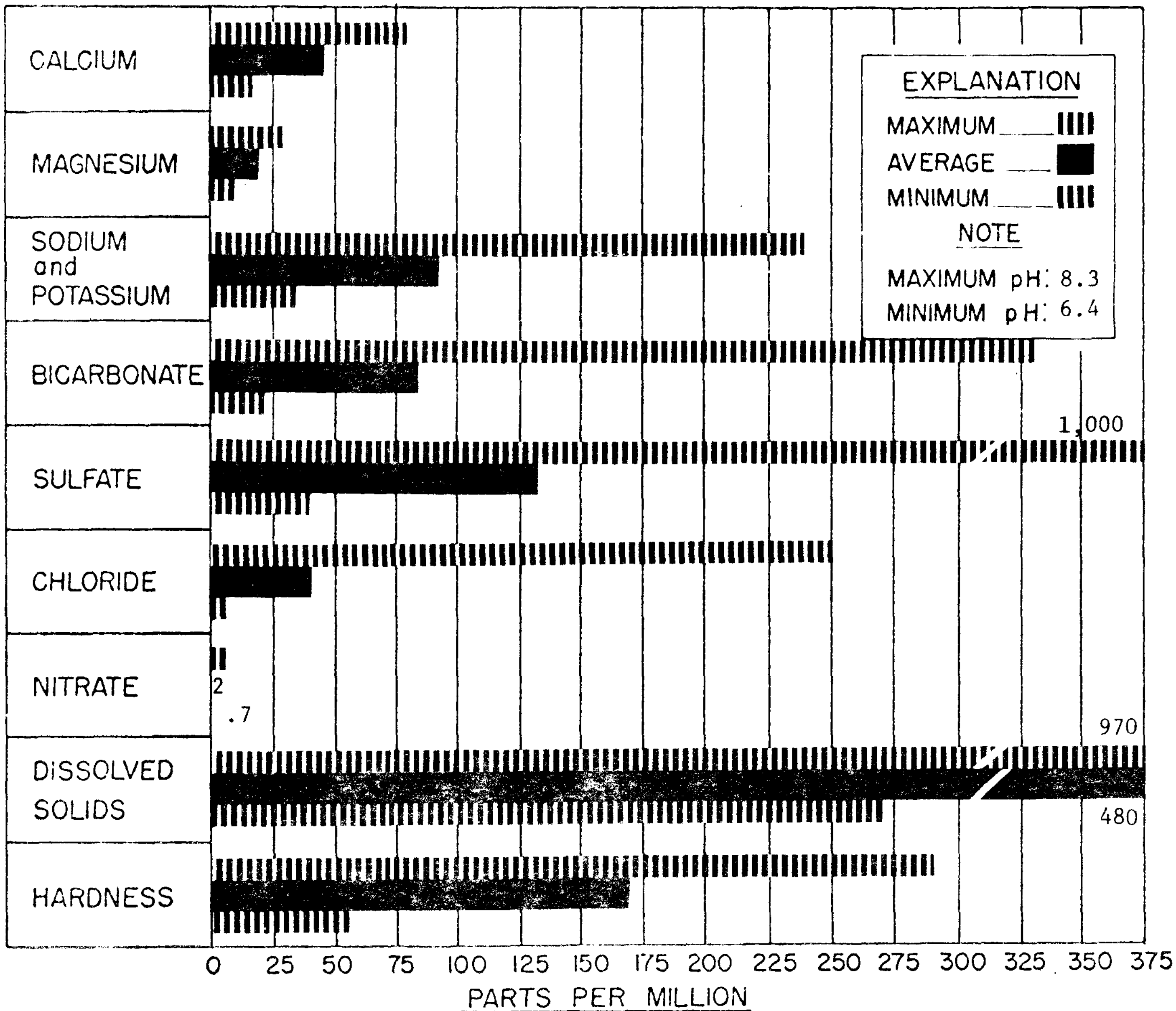
A. Description of Sampling Stations

Data for which the discussion of water quality in this report is based was collected from four sampling stations. Three of these stations are located on the Cumberland River itself at (1) Harlan, (2) Barbourville, and one below Lake Cumberland at (3) Burkesville. The fourth is located on the Yellow Creek at Middlesboro selected to reflect the effects of a coal mining area and an industrial waste discharge. Total drainage area encompassed by these stations, including the portion in Tennessee, is 6,152 sq. mi. with the Harlan station, 374 sq. mi., the Middlesboro station, 103 sq. mi., Barbourville, 1,034 sq. mi., and Burkesville, 6,152 sq. mi.

B. General Chemical Water Quality

The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The chemical characteristics of a stream when viewed over a long period of time is primarily from surface water. The type of rock formation and soils which the surface water contacts causes this predominate chemical characteristic. The contribution of groundwater, which is generally higher in dissolved solids than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky is one of moderate hardness caused by calcium and magnesium salts. The influence of mining activities is clearly indicated when the sulfate content increases to a higher level than the bicarbonate content, and the pH is on the acid side, below pH 5.5.

The general chemical water quality of the Upper Cumberland River Basin is characterized by Figures E-2 through E-5 which indicate a water with moderate mineralization as reflected by the hardness on E-2 and the combination of calcium and magnesium on E-4 which results in the equivalent hardness as shown in Burkesville.



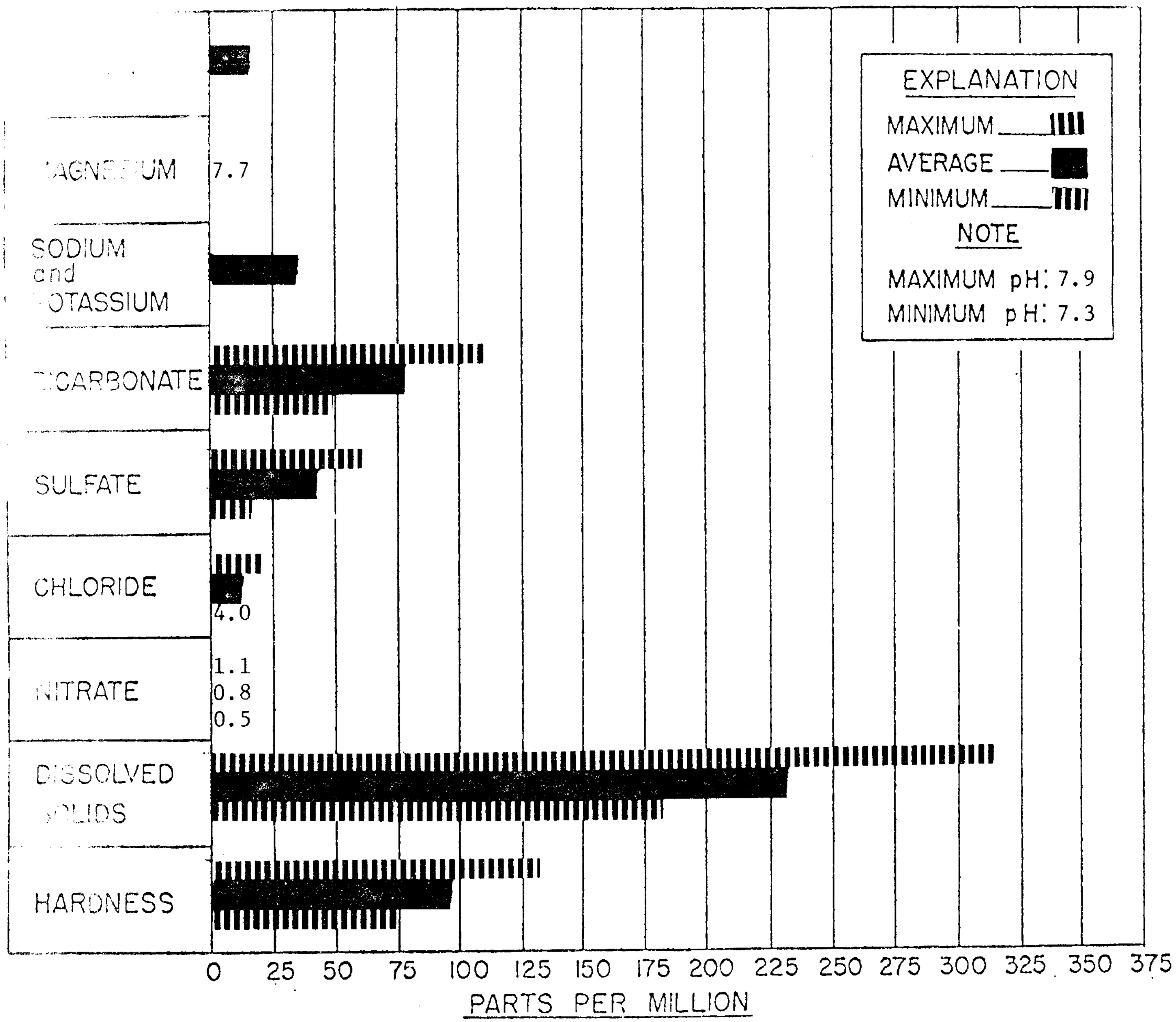
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE E-1

Yellow Creek

Middlesboro

5-64 to 11-74



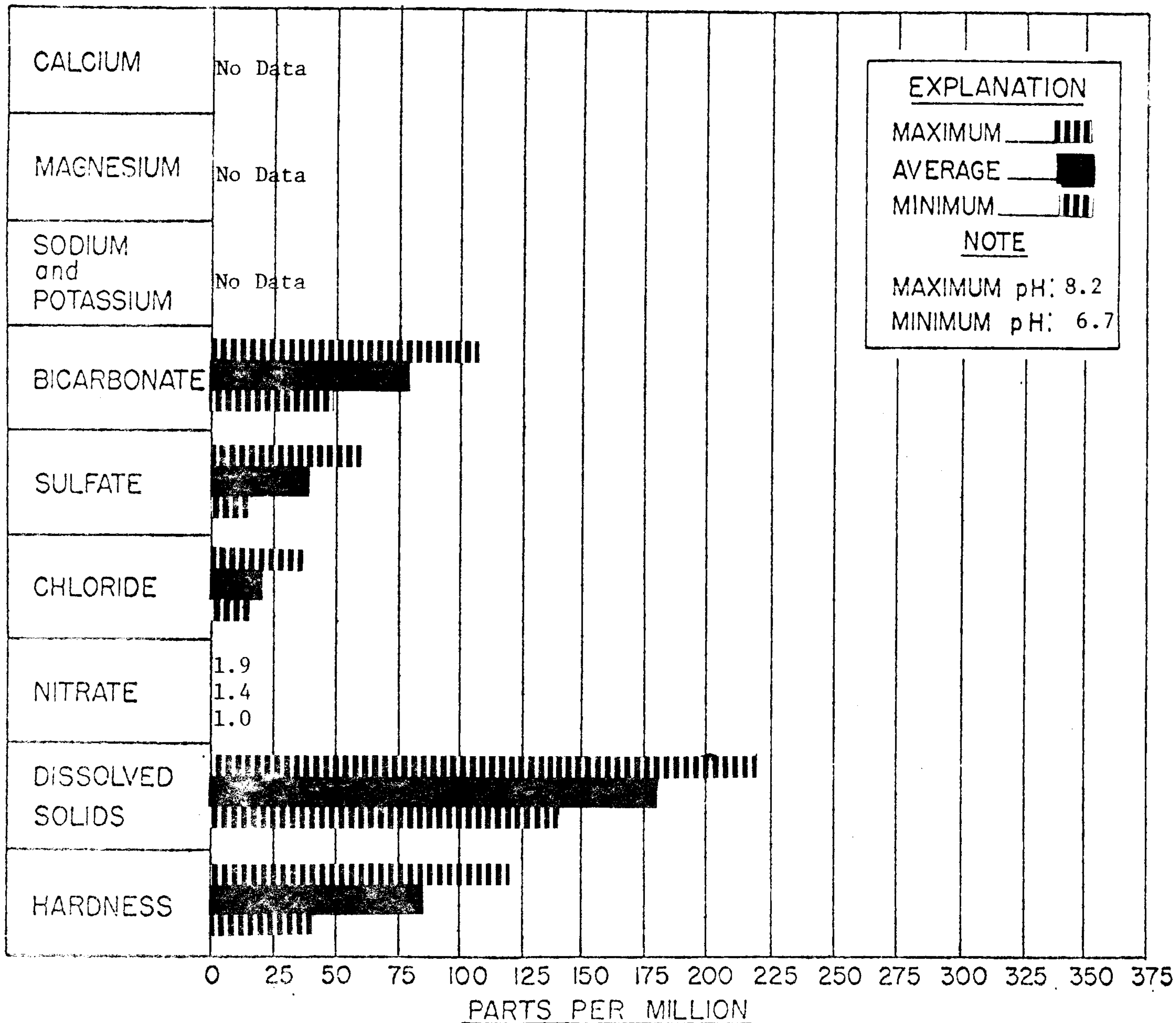
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE E-2

Cumberland River

Pineville

5-60 to 9-72



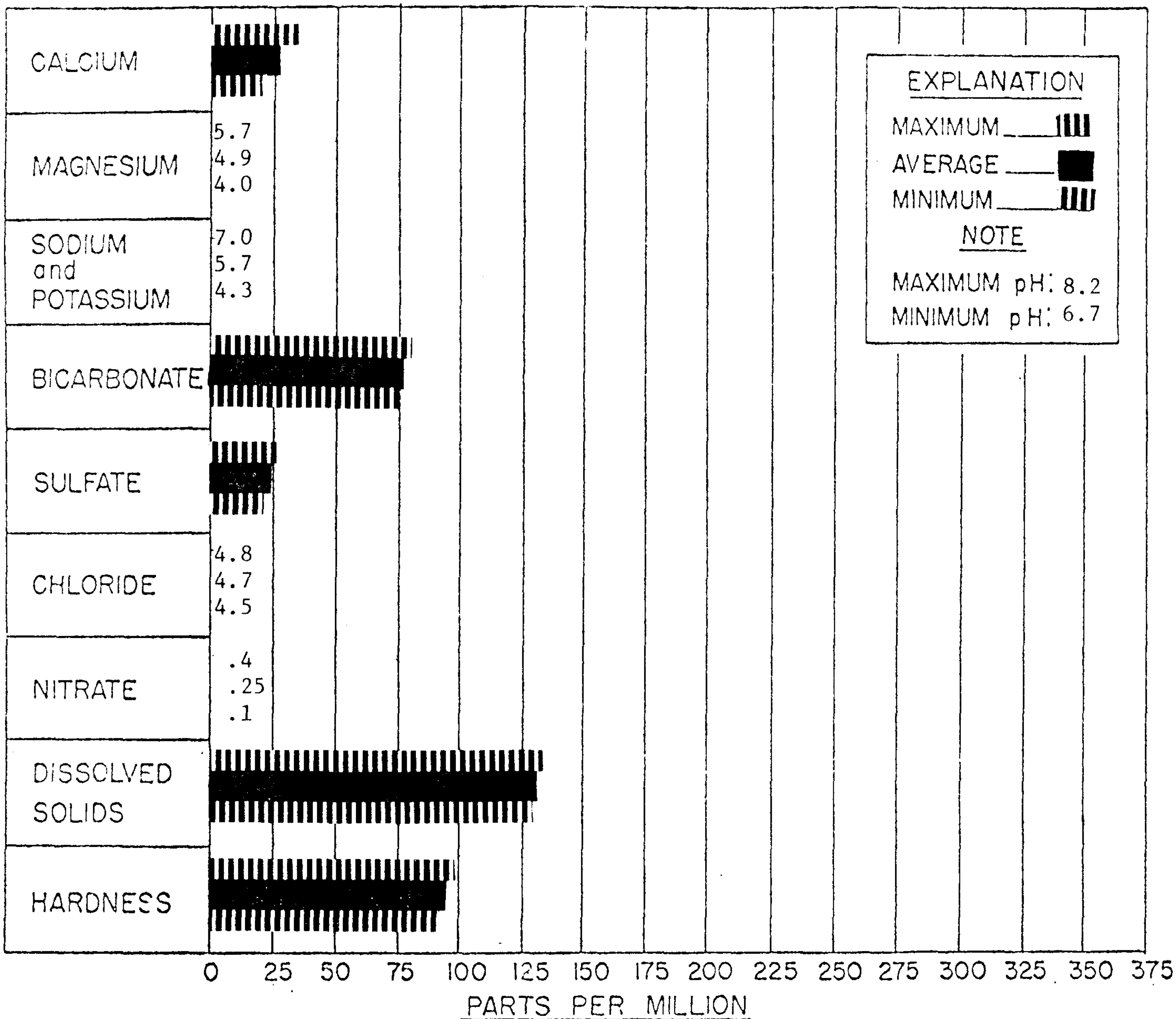
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE E-3

Laurel River

Corbin

10-65 to 9-72



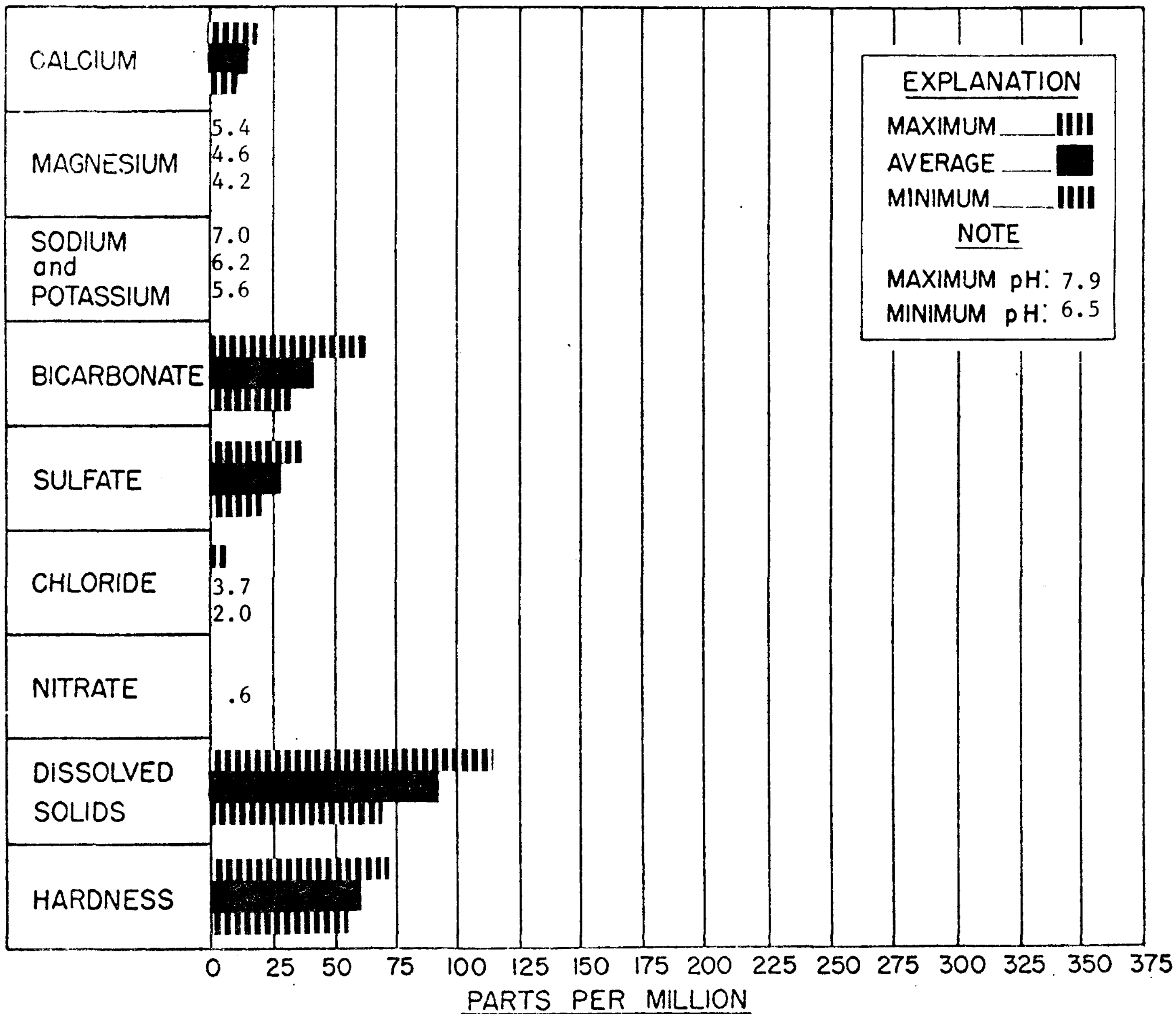
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE E-4

Rockcastle River

Billows

5-60 to 12-75



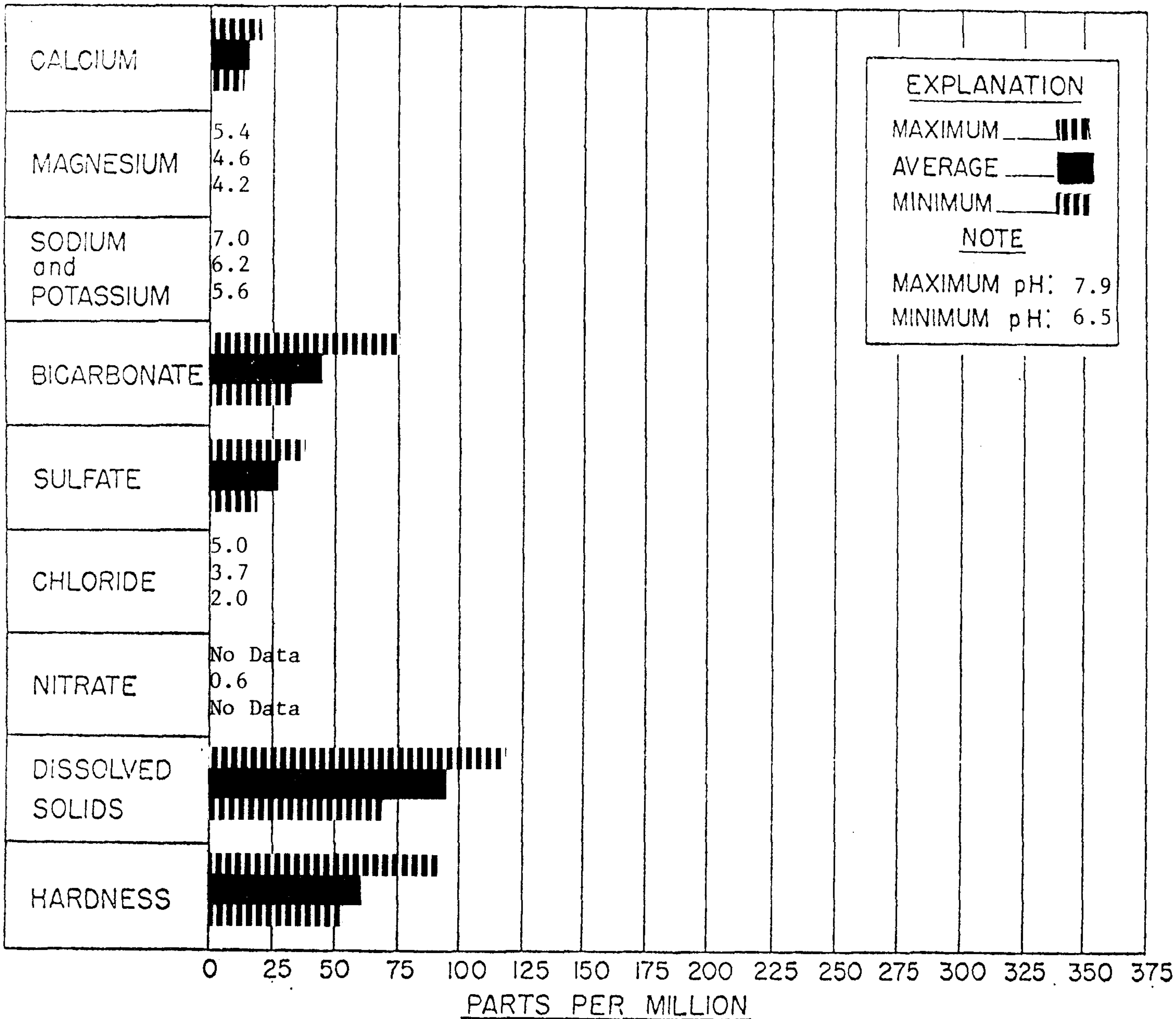
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE E-5

Cumberland River

Burkesville

12-65 to 5-72



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE E-6

Cumberland River

Burkesville

12-65 to 5-72

The water quality shown on Yellow Creek is not typical of the river as a whole but was selected to indicate the effect of natural conditions and man-made conditions on water quality. The source of water quality of Yellow Creek is an impoundment known as Fern Creek some 1,000 feet above the city of Middlesboro. Middlesboro is situated in a geological structure. This area is filled with sedimentation containing a high amount of organic material and as a result of seepage from this material, high sulfates, tannins, lignens, and low D.O. upstream of any waste discharges cause a major modification of the water from Fern Lake which has very little mineralization.

The city of Middlesboro, in addition to treating the municipal waste, has a facility which treats tannery wastes which compounds the problem of increasing the mineralization and particularly the sodium chloride portion. The effects of coal mining will particularly be exhibited on Yellow Creek in Middlesboro in spite of the fact that the sulfate concentration is relatively high.

C. Trace Chemical Water Quality

Trace elements (under 5 mg/l) are separated from the general chemical background of this report because of their influence on human health. Generally, these materials are "heavy" metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State-Federal Water Quality Standards. The standard for iron was exceeded twice at Harlan and Barbourville and once at Williamsburg. These excesses can be directly or indirectly attributable to surface mining as well as other types of runoff.

D. Waste Load Effects on Water Quality

Biochemically degradable wastes impose a load on the dissolved oxygen recourses of a stream. Such discharges affect water quality based upon the relationship between amount of discharge and amount of flow in the stream.

Also, as mentioned previously, the slope plays an important part in the ability of a stream to revive itself after being subject to organic waste loads. To determine the effects of waste loads on a stream a model has been developed in conjunction with the river basin planning effort and this model was used to determine the load effects on the streams. The Upper Cumberland Basin has a total of 752 miles of stream which carry effluent from treated organic loads. Of this total length, 176 miles are adversely affected by discharges, i.e., the dissolved oxygen level is predicted to be below 5 mg/l during period of low flow. It is interesting to note that of the 176 stream miles affected only 14 per cent of the length is affected by 90 per cent of total flow of the discharges. This 90 percent is composed of six (6) municipal discharges. The remaining discharges are small treatment plants scattered throughout the basin located on streams that normally possess zero flow during periods of most years.

E. Non-Point Source Effects

The topography of the area creates an inherent problem of erosion and sediment. Surface erosion is occurring on approximately 114 sq. mi. of rural areas, including surface mines, mine haul roads, logging roads and trails, log concentration yards, rural roads, streambanks, and utility rights-of way. This includes about 78 sq. mi. acres of inadequately treated croplands. Added to these figues are those sites in and around urban areas comprising approximately 9.5 sq. mi. that are being developed for residential, commercial, and industrial purposes.

Due to the growing urban areas of Middlesboro and Somerset runoff from these areas will increase the effect on the zero flow streams to which they are adjacent.

F. Water Uses

Of the many communities, industrial, and private users, three (3) withdraw over one million gallons per day. These are Middlesboro, Somerset and Corbin and they withdraw from surface waters for both industrial and public supply. The total basin withdrawal of all users is approximately 10,845,000 gallons per day of which 83 per cent is drawn from surface water and 70 per cent of the total is for public supply.

The Upper Cumberland Basin is a major area in the state with Lake Cumberland being the recreational main attraction, one of the large man-made lakes in the world. Also, Laurel River Lake and the portion of Dale Hollow Lake in Kentucky provide additional recreational facilities, as do the many smaller lakes in the area. This basin is considered one of the most important fishing areas of the state. Approximately 1,040 miles of stream are considered of fishery importance with some 440 miles affected by discharges.

G. Water Quality Changes

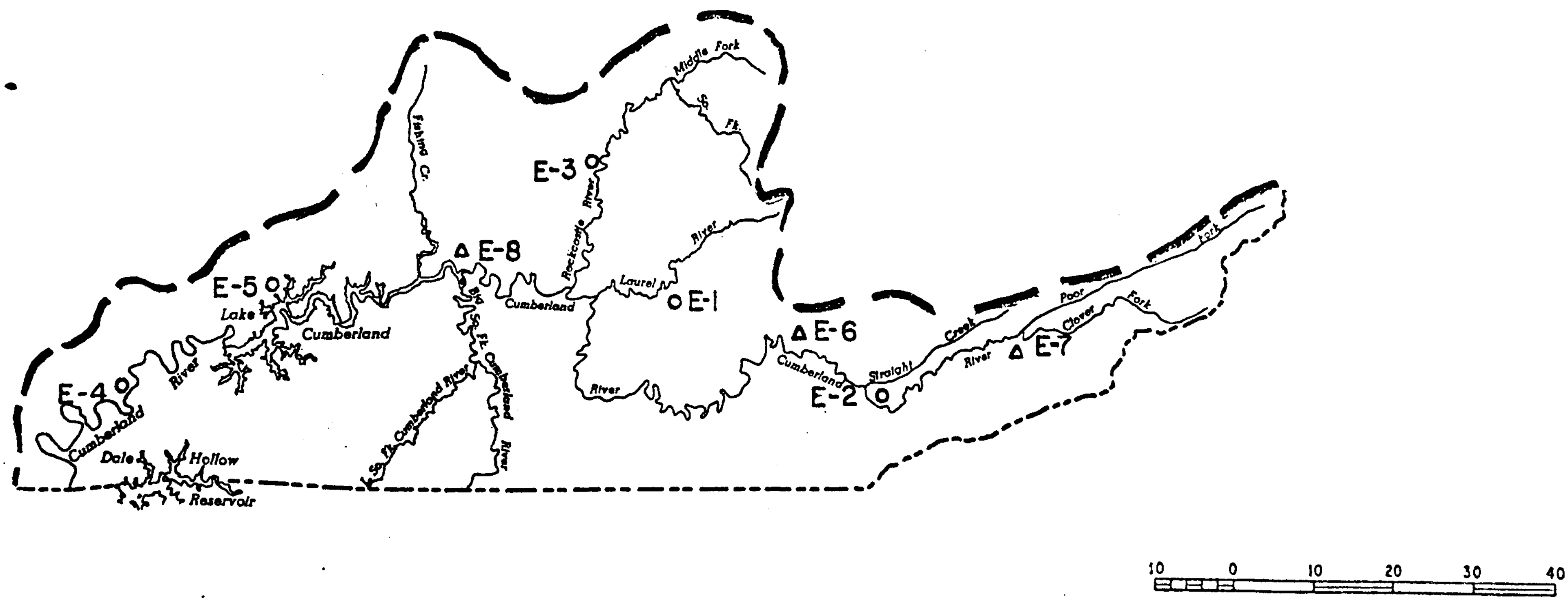
The water quality in the Upper Cumberland River Basin with the exception of that water quality in Yellow Creek and some of the tributaries above Harlan is excellent and low in mineralization and hardness. Any changes in water quality will be as a result of a marked increase in coal mining activities particularly in Harlan, Bell, Knott, and Whitley Counties. Waste from coal mining activities include acid mine drainage, however, the coal formations are not associated with high acid mine drainage production and sedimentation from surface disturbances particularly stripping and augering. The other effect on water quality where slight changes will occur is in the London-Corbin area where an ideal location for industrial development is expected to develop. The waste from this type of operation, however, is controllable and will not create major changes in the water quality of this area.

III. Water Quality Summary

Generally, it can be said the Upper Cumberland Basin is of good water quality. Nowhere along the main stem does the dissolved oxygen content fall below the minimum standard concentration of 5 mg/l. As discussed, the tributaries, due to the scattered discharges and low stream flows, are affected in regard to water quality. Improvements may be made either by improving treatment where appropriate or by improving operation. With the continuing technological improvements, better qualified operators are needed with better training and higher salaries to insure integrity in the sewage treatment plant's operation and maintenance.

The coal mining boom, due to the energy crisis and the abundance of coal as a fuel, may have a devastating effect on the water quality of this basin. Increased non-point source discharge due to the additional clearing of land will cause erosion and coal solids concentrations to be higher. Proper construction and drainage controls are needed to insure that under normal conditions coal solids are not discharged into the waters of the basin. More point source discharges in the form of preparation plants and coal washers will develop but should be kept in control by state issued operation permits and inspection as is done now. Cooperation is needed between all persons involved so that the Upper Cumberland River Basin will not only serve as a vital natural resource area, but will retain its recreational and environmental appeal.

UPPER CUMBERLAND RIVER



Base Data: U. S. Geological Survey

STATION KEY

E-1 LAUREL RIVER AT CORBIN
E-2 CUMBERLAND RIVER AT PINEVILLE
E-3 ROCKCASTLE RIVER AT BILLOWS
E-4 CUMBERLAND RIVER AT BURKESVILLE
E-5 CUMBERLAND RIVER AT ROWENA
E-6 CUMBERLAND RIVER AT BARBOURVILLE
E-7 CUMBERLAND RIVER AT HARLAN
E-8 LAKE CUMBERLAND AT SOMERSET

TABLE E-1

Sub-basins of 200 sq. mi. or Greater

Sub-basins		Square Miles
Clover Fork		222.0
Clear Fork		370.0
Laurel River		289.0
Rockcastle River		763.0
Bucky Creek		294.0
Clear Creek		283.0
South Fork Cumberland River		1,382.0
Beaver Creek		234.0
	Total	3,837.0

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e River Basin Planning Effort.

TABLE E 2

UPPER CUMBERLAND DRAINAGE AREA BY COUNTY

County	Total Area (sq. miles)	Area in Basin (sq. miles)	County	Total Area (sq. miles)	Area in Basin (sq. miles)
Adair	370	55	Letcher	339	50
Bell	370	355	Lincoln	340	80
Casey	435	44	McCreary	418	418
Clay	474	47	Metcalfe	296	45
Clinton	190	190	Monroe	334	110
Cumberland	310	310	Pulaski	653	653
Harlan	469	420	Rockcastle	311	251
Jackson	337	200	Russell	238	170
Knox	373	335	Wayne	440	440
Laurel	446	446	Whitley	458	458
			Total	7,601	5,077

SOURCE: Rand McNally Standard Reference Map and Guide of Kentucky, 1972.

TABLE E-3

Slopes and Elevations in Upper Cumberland River Basin

STREAM	LENGTH (Miles)	Max. El. (m.s.l.)	Min. El. (m.s.l.)	AVERAGE SLOPE (ft./miles)
Poor Fork Cumberland River	46.05	1,780	1,150	13.7
Yellow Creek	18.13	1,140	996	7.9
Clear Creek	4.82	1,194	985	43.4
Straight Creek	23.0	1,740	980	33.0
Clear Fork	18.6	938	896	2.3
Laurel Creek	10.31	1,340	955	37.3
Little Laurel River	19.3	1,160	1.030	6.7
Laurel River (above Lake)	30.05	1,200	982	7.3
Laurel River (below Lake)	2.3	767	737	13.0
Rockcastle River	69.2	1,015	723	4.2
Buck Creek	58.0	1,100	723	6.5
Pittman Creek	34.25	1,100	730	10.8
Cumberland River (above Lake)	190.8	2,049	723	6.95
Cumberland River (below Lake)	75.4	545	500	0.6

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e River Basin Planning Effort.

TABLE E-5

MAJOR LAKES IN THE UPPER CUMBERLAND RIVER BASIN

Location	County	Surface Area (Acres)	Capacity Acre-Feet
Cranks Creek	Harlan County	219	6,400
Fern Lake	Bell County	[illegible]01	902
Wood Creek Lake	Laurel County	672	23,270
Renfro Lake	Rockcastle County	274	4,404
Corbin Reservoir	Laurel, Knox, and Whitley Counties	139	2,500
Tyner Lake	Jackson County	87	2.364
Cannon Creek Dam	Bell County	243	11,300
	Total ----------------	1,735	51,140
Federal			
Laurel River Lake	Laurel and Whitley Counties	6,060	435,600
Lake Cumberland	Clinton, Russell, and Wayne Counties	63,530	6,089,000
Dale Hollow Lake	Cumberland and Clinton Counties	30,990	1,706,000
	Total ----------------	100,580	8,230,000
	Grand Total ----------------	102,315	8,281,140

SOURCE: Kentucky Department for Natural Resources and Environmental Protection, Division of Water Resources.

TABLE E-6

Organic Loads Affecting Streams in the Upper Cumberland River

Length of streams to which treated organic loads are discharged		752
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow		176
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow due to	Municipal Discharges	25
	Industrial Discharges	---
	Other Discharges	151

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e river basin planning effort. The values indicated the stream miles in which the dissolved oxygen is predicted to be less than 5 mg/l when the stream flow is less than the once in ten year, seven day, low flow.

Table E-7

City Population and Facility Grant Status in the Upper Cumberland River Basin in Kentucky

County	City	Population	Project Type	Comments
Adair				
Bell	Middlesboro	11,700	1	Active
	Pineville	2,817	1	Active
Casey				
Clay				
Clinton	Albany	1,891	1	Active
Cumberland	Burkesville	1,717	1	Active
	Marrow Bone W. D.	200	1	Active
Harlan	Harlan	3,200	1	Active
	(Loyall)	1,212		
	Evarts	1,182	1	Active
	Cumberland-	3,624	1	Active
	(Benham)	1,000		
	(Lynch)	1,700		
Jackson	McKee	255	1	Active (EDA Grant)
Knox	Barbourville	3,549	1	Active
	Corbin	2,000	1	Active
Laurel	(London)	4,377	1	Active
Letcher				
Lincoln				
McCreary	McCreary County W. D.		1	Active
	(Whitley City)	1,060		
	(Stearns)	950		
Metcalfe				
Monroe				

Table E-7
Continued

Pulaski	Somerset	10,500	1, 2, & 3	Active
	Burnside	586	None	No Sewers
Rockcastle	Mount Vernon	1,639	1	Active
	Livingston	338	1	No Sewers (EDA Grant)
Russell	Jamestown-	1,027	None	Sewers/STP
	(Russell Springs)	1,641	None	Sewers/STP
Wayne	Monticello	3,618	None	Sewers/STP
Whitley	Corbin	4,785	1	Active
	Williamsburg	3,687	1	Active

Source: Kentucky Department for Natural Resources and Environmental Protection, Division of Water Quality.

NOTE: Project type is related to the grant process step applied for or active for each municipality. Step 1 is the preliminary studies (201 Facilities Plan) required before design of the facilities. Step 2 is the design phase of the project, and Step 3 is the construction of facilities for the collection and treatment of wastewaters.

The comments relate to the status of the grant. Active indicates the project is funded and underway. Pending indicates that application for a grant has been made and is pending approval. No sewers indicates that the municipality does not presently have a comprehensive sewer system. Sewers/STP indicates the municipality is now served by sewers and treatment facilities.

The source of this information was the 1970 U. S. Census and the FY 77 construction grants list for Kentucky.

Table E-8

Water Quality Data for the Upper Cumberland River Basin

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
STORET #00400	pH Specific Units Kentucky Standard 6-LT-pH-LT-9						
Laurel R., Corbin	71/11/16	72/09/08	7.9	8.2	7.6	2	.424
U.S.G.S. 03405000	65/10/20	72/09/08	7.4	8.2	6.7	4	.648
Cumberland R. Pineville U.S.G.S. 03403000	60/05/03	72/09/07	7.6	7.9	7.3	4	.250
Rockcastle R., Billows	71/11/11	72/08/31	7.4	7.5	7.4	2	.071
U.S.G.S. 03406500	60/05/05	72/08/31	7.3	7.5	7.0	4	.222
Cumberland R., Burkesville	70/02/02	72/05/01	7.2	7.4	6.9	7	.227
U.S.G.S. 03414110	65/12/06	72/05/01	7.2	7.9	6.5	25	.353
STORET #00095	Conductivity Micromhos Kentucky Standard 800 micromhos						
Laurel R., Corbin	71/11/16	72/09/08	298.5	345.0	252.0	2	65.8
U.S.G.S. 03403000	65/10/20	72/09/08	294.0	401.0	178.0	4	98.8
Cumberland R., Pineville U.S.G.S. 03403000	60/05/03	72/09/07	382.3	495.0	294.0	4	91.3
Rockcastle R.,	76/01/05	76/08/13	155.0	220.0	89.9	4	53.20
Billows	71/11/11	75/09/02	197.8	223.0	145.0	4	35.64
U.S.G.S. 03406500	60/05/05	76/08/13	174.0	223.0	89.9	10	44.63
Cumberland R.,	70/02/02	72/05/01	141.8	174.0	110.0	8	21.1
Burkesville	65/12/06	72/05/01	148.9	203.0	110.0	28	17.9
STORET #70300	Dissolved Solids, milligrams per liter Ky. Std. 500 mgl						
Laurel R., Corbin	71/11/16	72/09/08	180.0	220.0	140.0	2	56.6
	71/11/16	72/09/08	180.0	220.0	140.0	2	56.6
Cumberland R., Pineville	60/05/03	72/09/07	230.0	316.0	180.0	3	74.8
Rockcastle R.,	76/06/21	76/06/21	134.0	134.0	134.0	1	--
Billows	71/11/11	75/09/02	116.5	132.0	86.0	4	21.079
	60/05/05	76/06/21	111.1	134.0	74.0	7	23.808

Table E-8
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
Cumberland R.,	70/02/02	72/05/01	88.7	107.0	71.0	7	13.2
Burkesville	65/12/06	72/05/01	90.5	117.0	70.0	25	11.8
STORET #00410	Alkalinity, mg/l, No Standard						
Laurel R., Corbin	71/11/16	72/09/08	62.0	75.0	49.0	2	18.4
	65/10/21	72/09/08	77.0	107.0	49.0	3	29.1
Cumberland R., Pineville	60/05/03	72/09/07	98.3	125.0	72.0	4	26.2
Rockcastle R.,	76/06/21	76/06/21	37.0	37.0	37.0	1	--
Billows	71/11/11	75/09/02	67.5	78.0	43.0	4	16.421
	60/05/05	76/06/21	61.9	78.0	37.0	7	18.289
Cumberland R.,	70/02/02	72/05/02	40.9	62.0	31.0	7	10.6
Burkesville	67/10/02	72/05/01	44.1	75.0	31.0	17	10.7
STORET #00900	Hardness, mg/l, 0-60 soft, 61-120 mod. hard, 120-180 hard, over 180 very hard						
Laurel R., Corbin	71/11/16	72/09/08	102.0	120.0	84.0	2	25.5
	65/10/20	72/09/08	85.5	120.0	42.0	4	32.6
Cumberland R., Pineville	60/05/03	72/09/07	96.7	130.0	74.0	4	23.7
Rockcastle R.,	76/06/21	76/06/21	63.0	63.0	63.0	1	
Billows	71/11/11	75/09/02	89.9	100.0	66.0	4	16.145
	60/05/05	76/06/21	81.6	100.0	60.0	7	18.013
Cumberland R., Rowena	65/05/20	65/05/20	54.0			1	
Cumberland R.,	70/02/02	72/05/01	59.3	70.0	54.0	7	6.0
Burkesville	65/12/06	72/05/01	61.5	92.0	53.0	25	8.2
STORET #00080	Color, Platinum Cobalt Color Units, Proposed EPA Std. 75 units						
Laurel R., Corbin	65/10/20	65/10/21	17.5	25.0	10.0	2	10.6
Cumberland R., Pineville	60/05/03	60/05/03	5.0			1	
Rockcastle R., Billows	60/05/05	61/09/15	8.0	10.0	6.0	2	2.8

Table E-8
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
Cumberland R., Rowena	65/05/20	65/05/20	6.0			1	
Cumberland R., Burkesville	70/02/02	70/02/02	5.0			1	
	67/10/02	70/02/02	3.3	5.0	0.0	3	2.9
STORET #00930	Sodium, mg/l No Standard						
Cumberland R., Pineville	60/05/03	60/05/03	32.0			1	
Rockcastle R., Billows	76/06/21	76/06/21	3.3	3.3	3.3	1	0.0
	75/06/13	75/09/02	3.3	4.2	2.3	2	1.3
Cumberland R., Burkesville	70/02/02	70/02/02	5.6			1	
	66/12/02	70/02/02	5.1	5.6	4.8	4	.379
STORET #00935	Potassium, mg/l No Standard						
Cumberland R., Pineville	60/05/03	60/05/03	1.9			1	
Rockcastle R., Billows	76/06/21	76/06/21	2.6	2.6	2.6	1	
	75/06/13	75/09/02	2.4	2.8	2.0	2	.566
	60/05/05	76/06/21	1.8	2.8	.4	5	.955
STORET #00940	Chloride, mg/l Proposed EPA Std. 25.0 mg/l						
Laurel R., Corbin	71/11/16	72/09/08	19.0	21.0	17.0	2	2.8
	65/10/20	72/09/08	22.3	34.0	17.0	4	8.1
Cumberland R., Pineville	60/05/03	72/09/07	11.7	20.0	4.0	4	6.7
Rockcastle R., Billows	76/06/2	76/06/21	2.7	2.7	2.7	1	0.0
	71/11/11	75/09/02	4.5	6.0	2.5	4	1.5
	60/05/05	76/06/21	3.6	6.0	2.0	7	1.5
Cumberland R., Rowena	65/05/20	65/05/20	2.2			1	
Cumberland R., Burkesville	70/02/02	72/05/01	3.1	4.2	2.3	7	.716
	65/12/06	72/05/01	3.7	5.0	2.0	25	.754
STORET #00945	Sulfate, mg/l Proposed EPA Std. 250 mg/l						
Laurel R., Corbin	71/11/16	72/09/08	53.0	61.0	45.0	2	11.3
	65/10/20	72/09/08	38.8	61.0	15.0	4	19.3

Table E-8
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
Cumberland R., Pineville	60/05/03	72/09/07	76.5	96.0	68.0	4	13.1
Rockcastle R., Billows	76/06/21	76/06/21	26.0	26.0	26.0	1	0.0
	71/11/11	75/09/02	23.8	27.0	19.0	4	3.6
	60/05/05	76/06/21	22.1	27.0	17.0	7	4.4
Cumberland R., Rowena	65/05/20	65/05/20	21.0			1	
Cumberland R., Burkesville	70/02/02	72/05/01	27.4	36.0	23.0	7	4.3
	65/12/06	72/05/01	26.1	36.0	20.0	25	4.0
STORET #00618	Nitrate, mg/l Proposed EPA Std. 10 mg/l						
Laurel R., Corbin	71/11/16	72/09/08	1.45	1.9	1.0	2	.636
	71/11/16	72/09/08	1.45	1.9	1.0	2	.636
Cumberland R., Pineville	71/11/17	72/09/07	0.8	1.1	0.5	2	.424
Rockcastle R., Billows	76/06/21	76/06/21	.55	.55	.55	1	0
	71/11/11	75/09/02	.24	.42	.05	4	.19
	71/11/11	76/06/21	.30	.55	.05	5	.22
Cumberland R., Burkesville	72/05/01	72/05/01	0.6			1	
	72/05/01	72/05/01	0.6			1	
STORET #00950	Fluoride, mg/l Ky. Std. 1.0 mg/l						
Laurel R., Corbin	71/11/16	72/09/08	0.4	0.5	0.3	2	.141
	71/11/16	72/09/08	0.4	0.5	0.3	2	.141
Cumberland R., Pineville	60/05/03	75/09/07	.77	2.0	0.1	3	1.07
Rockcastle R., Billows	76/06/21	76/06/21	0.0	0.0	0.0	1	
	71/11/11	75/09/02	.10	.2	.0	4	.08
	60/05/05	76/06/21	.11	.3	.0	7	.11
Cumberland R., Burkesville	70/02/02	72/05/01	0.13	0.3	0.0	4	.126
	66/12/02	72/05/01	0.11	0.3	0.0	7	.107
STORET #00915	Calcium, mg/l No Standard						
Cumberland R., Pineville	60/05/03	60/05/03	17.0			1	

Table E- 8
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
Rockcastle R., Billows	76/06/21	76/06/21	18.0	18.0	18.0	1	
	75/06/13	75/09/02	25.5	31.0	21.0	2	7.8
	60/05/05	76/06/21	23.2	31.0	18.0	5	5.9
Cumberland R., Burkesville	70/02/02	70/02/02	21.0			1	
	66/12/02	70/02/02	18.8	21.0	16.0	4	2.2
STORET #00925	Magnesium, mg/l No Standard						
Cumberland R., Pineville	60/05/03	60/05/03	7.7			1	
Rockcastle R., Billows	76/06/21	76/06/21	4.5	4.5	4.5	1	
	75/06/13	75/09/02	4.9	5.7	4.0	2	1.2
	60/05/05	76/06/21	4.5	5.7	3.2	5	.9
Cumberland R., Burkesville	70/02/02	70/02/02	4.2			1	
	66/12/02	70/02/02	4.6	5.4	4.2	4	.548
STORET #01025	Cadmium, micrograms per liter, Ky. Std. 100 ug/l						
Cumberland R., Barbourville	75/08/04	75/09/04	0.0	0.0	0.0	2	0.0
Rockcastle R., Billows	76/01/05	76/08/13	1.5	3.0	0.0	4	1.3
	75/07/31	75/09/02	4.0	8.0	0.0	2	5.7
Cumberland R., Rowena	76/02/04	76/08/03	4.3	10.0	2.0	4	3.9
	75/08/05	75/12/01	1.5	2.0	1.0	2	0.7
	75/08/05	76/08/03	3.3	10.0	1.0	6	3.3
STORET #01056	Manganese, ug/l. Proposed Ky. Std. 50 ug/l						
Cumberland R., Burkesville	72/05/01	72/05/01	13.0			1	
	72/05/01	72/05/01	13.0			1	
STORET #01046	Iron, ug/l Proposed EPA Std. 300 ug/l						
Cumberland R., Burkesville	72/05/01	72/05/01	50.0			1	
	72/05/01	72/05/01	50.0			1	
STORET #01030	Chromium, ug/l. Ky. Std. 50 ug/l						
Cumberland R., Barbourville	75/08/04	75/09/04	0.0	0.0	0.0	2	0.0

Table E- 8
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
Rockcastle R., Billows	76/01/05	76/08/13	3.5	14.0	0.0	4	7.0
	75/07/31	75/09/02	2.5	5.0	0.0	2	3.5
Cumberland R., Rowena	76/02/04	76/08/03	0.0	0.0	0.0	4	0.0
	75/08/05	75/12/01	5.0	10.0	0.0	2	7.1
STORET #01049	Lead, ug/l, Ky. Std. 50 ug/l						
Cumberland R., Barbourville	75/08/04	75/09/04	0.0	0.0	0.0	2	0.0
Rockcastle R., Billows	76/08/05	76/08/13	6.5	10.0	0.0	4	4.5
	75/07/31	75/09/02	38.5	70.0	7.0	2	44.5
Cumberland R., Rowena	76/02/04	76/08/03	10.0	14.0	3.0	4	5.0
	75/08/05	75/12/01	7.0	8.0	6.0	2	1.4
STORET #01000	Arsenic, ug/l, Ky. Std. 50 ug/l						
Cumberland R., Barbourville	75/08/04	75/09/04	0.5	1.0	0.0	2	.707
Rockcastle R., Billows	76/01/05	76/08/13	0.0	0.0	0.0	4	0.0
	75/07/31	75/09/02	0.0	0.0	0.0	2	0.0
Cumberland R., Rowena	76/02/04	76/08/03	0.0	0.0	0.0	4	0.0
	75/08/05	75/12/01	0.0	0.0	0.0	2	0.0

Bacteriological Data

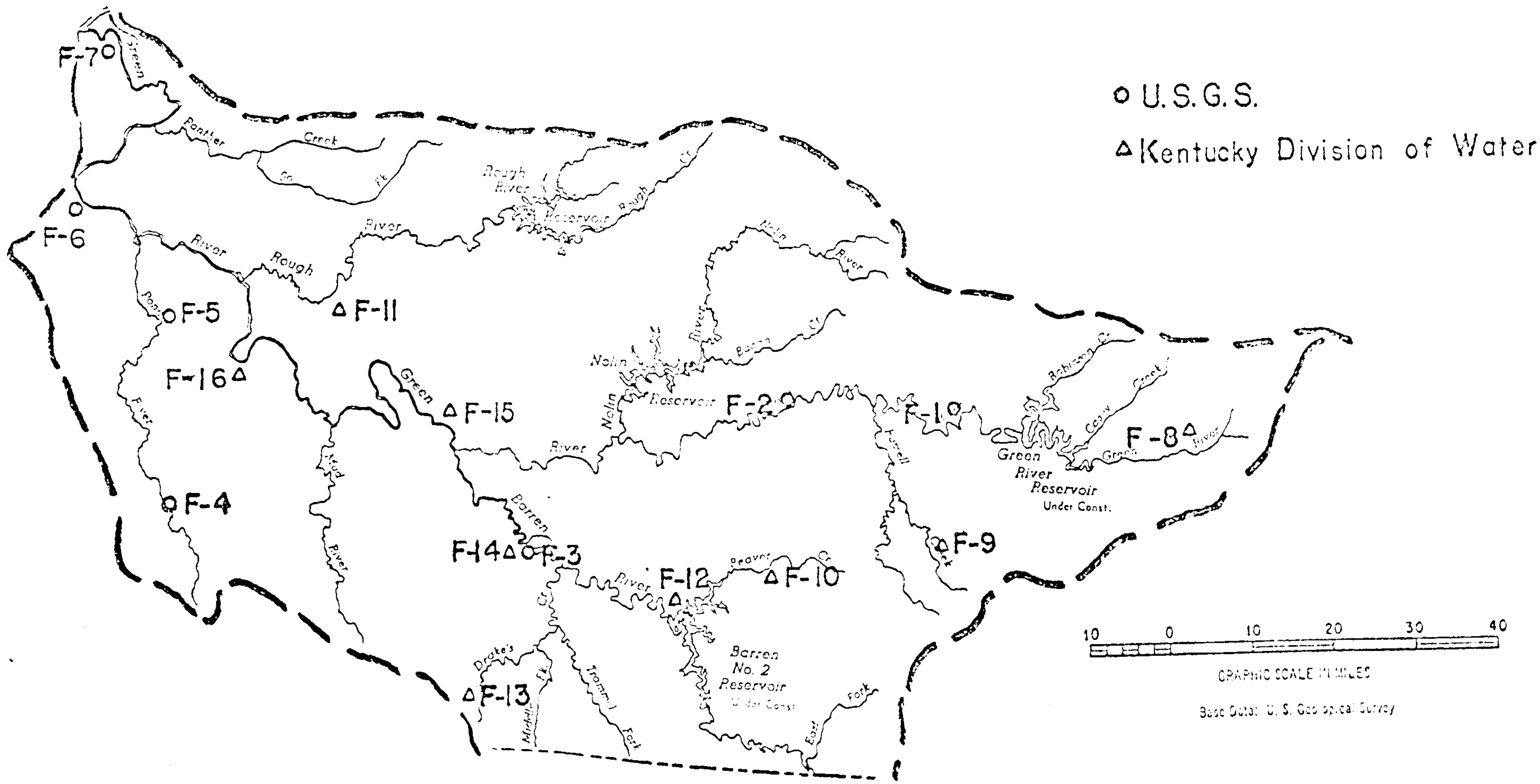
Storet #31503 Total Coliform colonies per 100 ml. Ky. Std. 1000/100ml.
Storet #31616 Fecal Coliform colonies per 100 ml.

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS
Poor Fork, Cumberland R.						
T. Coli.	75/02/26	75/11/17	14,000	26,826	800	9
F. Coli.	75/02/12	75/10/30	9,965	59,000	20	7
Cumberland R., Harlan						
T. Coli.	75/02/13	75/11/11	12,968	38,000	1900	11
F. Coli.	75/02/13	75/07/31	693	1,200	300	6
Cumberland R., Pineville						
T. Coli.	75/02/15	75/11/11	5,909	31,000	1400	11
F. Coli.	75/02/13	75/07/28	635	1,700	160	6
Laurel R., Corbin						
T. Coli.	75/05/11	75/11/11	681	3,400	80	10
F. Coli.	75/02/11	75/05/22	90	300	0	4

Table E- 8
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
Lake Cumberland, Somerset							
T. Coli.	75/01/06	75/12/04	159	745	0	14	
	74/03/25	75/12/04	118	745	0	28	
F. Coli.	74/10/07	75/02/18	50	156	0	8	
	75/01/06	75/02/18	58	140	3	4	

GREEN RIVER



o U.S.G.S.
Δ Kentucky Division of Water
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Green
Panther
Creek
Rough River Reservoir
Rough
River
Nolin
Reservoir
Bacon
Cr
Robinson Cr
Casey Creek
Green River Reservoir
Under Const.
Barren
Mud
Drake's
Middle
Trammel
Fork
Beaver
Barren No. 2 Reservoir
East Fork
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THE GREEN RIVER BASIN

The Green River Basin is located in West Central Kentucky and Northern Tennessee. The first section of this report will deal with the general description of the area. The second section will enter into an analysis of the water quality in the basin, its causes and effects. The third section of the report summarizes the water quality of the basin and the correction needs.

I. A Description of the Green River Basin

A. Geography

The Green River Basin is located in West-Central Kentucky and in Northern Tennessee. It comprises a total drainage area of 9,229 sq. mi., with 8,821 in Kentucky and 408 in Tennessee. The Green River Basin encompasses all or portions of 31 counties in Kentucky and 3 in Tennessee. (The Kentucky County Areas are listed in Table F-1 of the Appendix). The Green River is a tributary of the Ohio River, the confluence of the Green River with the Ohio River is 197 miles above the mouth of the Ohio River. The main tributaries of the Green River are the Barren, Nolin, Pond and Rough Rivers. These and other sub-basins with drainage basin areas over 200 sq. mi. are listed in Table F-2 in the Appendix.

B. Topography

The primary interest is in the character and slopes of the land and the streams within the basin as they affect water quality. The slope of the land is one of the variables which contributes to water quality. The character indicates the type of land over which the runoff travels before entering the stream. The largest portion of the Green River Basin is in the physiographic region known as the Mississippian Plateau which can be characterized as gently rolling fields, rocky hillsides, and Karst topography. Karst topography has many sinkholes, underground solution channels and caves. Some wastewater treatment plants and storm water runoff are discharged in the underground formations since the region is without surface streams. The second largest physiographic region is the Western Kentucky Coal Fields with somewhat higher elevations and generally more rugged than the Mississippian Plateau Region. The Mississippian Plateau Region has a lower quantity of runoff and higher runoff quality than the Western Kentucky Coal Field Region.

The quality of the water in a stream can be influenced by the slope of the stream. This effect is demonstrated in the direct relationship between the slope and the capacity of the stream to assimilate waste loads through reaeration. A stream slope of 2 ft./mi. or less produces a low rate of reaeration. A stream slope between 2 and 6 ft./mi. produces a moderate rate of reaeration. Slopes between 6 and 10 ft./mi. produces a high rate of reaeration. The main stem of the Green River flows into the Ohio River at elevation 338 feet above mean sea level (m.s.l.) and is controlled by a series of six locks and dams for navigational purposes. These structures with mile points and pool lengths are listed in Table F-3. Past these structures the river then rises at a gradual slope of 1.6 ft./mi. to the Green River Reservoir at elevation 600 feet above m.s.l. The tributary slopes range from 0.8 ft./mi. to 3 ft./mi. in the lower reaches and 4.7 ft./mi. to 7.7 ft./mi. in the upper regions and the highest elevation is 1,040 feet above m.s.l. A complete list of slopes is included in Table F-2 of the Appendix.

C. Geology

Surface water quality in the Green River Basin is affected by the parent bedrock, mineral resources and groundwater The base parent material for most of the Green River Basin is limestone bedrock which produces a bicarbonate type hardness in the water. The Pond River and Rough River sub-basins have sandstone and shale rock layers which produce a sulfate type hardness in the water.

The major mineral resources of the Green River Basin are coal, oil and gas with coal being the largest resource. Generally, coal production in this basin increases acidity and mineralization in the stream. Approximately 40 million tons of coal was produced in the basin in 1972, 94% of which was mined in 3 counties, Muhlenberg (65%), Ohio (16%) and Hopkins (13%). These and other county coal productions are listed in Table F-4 of the Appendix. Approximately 75% of the basin's production in 1972 was done by strip mining on 12.5 sq. mi. A "Soil Conservation Service" basin study indicates about 264 sq. mi. of strip mineable coal still exists. The Green River Basin contributed one-third of the total coal production in 1972, and it has been estimated that coal production in Kentucky by 1985 will reach 400 million tons per year, 3 1/3 times the 1972 figure. A copy of the Commonwealth of Kentucky strip mining slope regulations is included in Table F-5 of the Appendix.

Other mineral resources in the Green River Basin are oil and gas. Oil wells in Kentucky can produce a brine as a waste product. Disposal of brine water other than by reinjection could degrade water quality. In the Green River Basin oil and gas production are not expected to increase in the future.

An important groundwater effect on water quality is the increase in assimilative capacity of the stream due to the substantial amounts contributed to the base flow by springs in the Mississippian Plateau during period of low flow.

Groundwater yields in the Green River Basin range from 50 gallons per minute (g.p.m.) or less in 75 percent of the basin; 50-500 g.p.m. in approximately 24 percent of the basin,and 500 to 1,000 g.p.m. in approximately 1 percent of the basin. A map of these regions is included in the Appendix.

D. Hydrology

The stream flow of the Green River Basin was obtained at six stations: (1) Nolin River at Kyrock, (2) Barren River at Bowling Green, (3) Rough River at the Falls of the Rough River, on the main stem of the Green River at (4) Munfordsville, (5) Lock Number 4 and (6) Lock Number 2. The low flows at all of these stations were augmented by Corps of Engineer Reservoirs. The low flow period for once in 10 years for 7-days is adjusted to include flow augmentation provided by the impoundments. The yields without augmentation are low and a large drainage basin area is needed before a flow occurs. In the Barren River Basin 100 sq. mi. of drainage area will be needed for 2 cubic feet per second/ square mile (c.f.s./sq.mi.) of low flow. Because of this flow condition water quality becomes increasingly difficult to maintain during periods of low flow.

The Karst topography (see Topography) has an influence on the hydrology of the Green River Basin. The sinkholes and underground solution channels store the runoff water during periods of high flows, and discharge this stored water through springs after the peak flow in the stream system has passed.

In addition to the streams mentioned there are 13 major lakes located within the basin, (Table F-7 of the Appendix). Nine of these are multiple purpose structures, two slurry dams for Peabody Coal Company, one flood retardent structure and one for recreation purposes. There are 4 Corps of Engineers Reservoirs with a total area of 29,090 acres at seasonal pool with a total volume of 532,000 acre feet. They are the Nolin River, Green River, Barren River, and Rough River reservoirs. They are all designed and operated for flood control, recreation, low flow augmentation and fish and wildlife purposes, and in addition the Green, Barren and Rough River Reservoirs have volume allocated for water supply. Lakes impounded by the U.S.D.A. Soil Conservation Service and others have 32,200 acre feet of volume. These lakes were not designed with the capability for low flow augmentation.

E. Population

The total population in the basin is 426,000 which is distributed uniformly except for major population centers located in Warren (Bowling Green; 36,400), Hardin (Elizabethtown; 11,700), Barren (Glasgow; 11,300), Hopkins (Madisonville; 15,300), and Muhlenberg (Greenville-Central City; 9,330) counties. Of these major cities Madisonville, Elizabethtown and Glasgow discharge to zero flow streams and have a measurable impact on water quality. Populations of the other basin counties are listed in Table F-8 of the Appendix with the municipalities listed in Table F-9 of the Appendix. The basin population is 35 percent urban and 65 percent rural.

TABLE F-13

SURFACE WATER RECORDS FOR THE GREEN RIVER BASIN

STATION	PERIOD OF RECORD	DRAINAGE AREA	AVERAGE FLOW	MAXIMUM FLOW	MINIMUM FLOW	7-day/10-yr. LOW FLOW
Nolin River at Kyrock	1 28 yr.	703 sq.mi.	892 cfs, 1.3cfs*/sq.mi.	22,700 cfs, 32cfs/sq.mi.	0 cfs	50 cfs
	wtr/yr 1976		1,017 cfs, 1.4cfs/sq.mi.	6,790 cfs, 10cfs/sq.mi.	0 cfs	
Barren River at Bowling Green	2 38 yr.	1,848 sq.mi.	2,540 cfs, 1.4cfs/sq.mi.	85,000 cfs, 46cfs/sq.mi.	44 cfs, 0.0cfs/sq.mi.	116 cfs
	wtr/yr 1976		3,284 cfs, 1.8cfs/sq.mi.	22,500 cfs, 12cfs/sq.mi.	205 cfs, 0.1cfs/sq.mi.	
Rough River at Falls of Rough	3 28 yr.	504 sq.mi.	741 cfs, 1.5cfs/sq.mi.	12,400 cfs, 25cfs/sq.mi.	6 cfs, 0.0cfs/sq.mi.	50 cfs
	wtr/yr 1976		809 cfs, 1.6cfs/sq.mi.	3,080 cfs, 6cfs/sq.mi.	69 cfs, 0.1cfs/sq.mi.	
Green River at Munfordville	4 50 yr.	1,673 sq.mi.	2,659 cfs, 1.6cfs/sq.mi.	76,800 cfs, 46cfs/sq.mi.	39 cfs, 0.0cfs/sq.mi.	152.4 cfs
	wtr/yr 1976		3,184 cfs, 1.9cfs/sq.mi.	21,500 cfs, 13cfs/sq.mi.	297 cfs, 0.2cfs/sq.mi.	
Lock No. 4 at Woodbury	5 39 yr.	5,403 sq.mi.	8,122 cfs, 1.5cfs/sq.mi.	205,000 cfs, 38cfs/sq.mi.	200 cfs, 0.0cfs/sq.mi.	319.9 cfs
	wtr/yr 1976		10,090 cfs, 1.9cfs/sq.mi.	49,500 cfs, 9 cfs/sq.mi.	1,020 cfs, 0.2cfs/sq.mi.	

Table F-13
Continued

STATION	PERIOD OF RECORD	DRAINAGE AREA	AVERAGE FLOW	MAXIMUM FLOW	MINIMUM FLOW	7-day/10-yr. LOW FLOW
Lock No. 2 at Calhoun	6 46 yr.	7,564 sq.mi.	10,960 cfs, 1.4cfs/sq.mi.	208,000 cfs, 27cfs/sq.mi.	280 cfs, 0.0cfs/sq.mi.	319.9 cfs
	wtr/yr 1976		12,760 cfs, 1.7cfs/sq.mi.	46,300 cfs, 6cfs/sq.mi.	1,180 cfs, 0.2cfs/sq.mi.	

* Cubic feet per second

1. Flow regulated since March, 1963 by Nolin Lake.
2. Flow regulated since March, 1964 by Barren River Lake.
3. Flow regulated since October, 1959 by Rough River Lake.
4. Flow regulated since February, 1969 by Green River Lake
5. Flow regulated by upstream lakes on Green, Barren, and Nolin River.
6. Flow regulated by upstream lakes on Green, Barren, Nolin, and Rough River.

NOTE: Data is taken from "Surface Water Records in Kentucky" by the United States Geological Survey. The 7-day/10-yr. low flow was taken from the waste load allocation produced as a component of the 303e River Basin Continuing Planning Process.

II. Basin Water Quality

A. Description of Sampling Stations

The recorded water quality of the basin is presented along with some of the major causes and effects. Also presented are the major uses of surface water in the basin description of the water sampling stations.

There were four stations used in this report to describe the typical water quality within the basin. The first station is on the main stem of the Green River at Munfordville covering 1,673 square miles (sq. mi.) or 18% of the Green River Basin. The second station is located at Bowling Green covering 1,848 sq. mi. or 82% of the Barren River Sub-basin. The third station is on the Green River approximately mid-river at Central City with 6,300 sq. mi. or 68% of the basin area above the station. The fourth station is on the main stem of the Green River near its mouth at Lock No. 1 covering 9,181 sq. mi. or 99% of the basin.

The Pond River near Sacramento was chosen to describe the effect of coal production on water quality in the Green River Basin. This station is located in the heart of the coal production of Western Kentucky. There is also limited oil production in this area. The drainage area above the station is 523 sq.mi. or 65% of the Pond River Sub-basin. The following discussion of parameters is based upon the data included in Table F-10 of the Appendix.

B. General Chemical Water Quality

The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The chemical characteristics of a stream when viewed over a long period of time is primarily from surface water. The type of rock formation and soils which the surface water contacts causes this predominate chemical characteristic. The contribution of groundwater, which is generally higher in dissolved solids than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky is one of moderate hardness caused by calcium and magnesium salts. The influence of mining activities is clearly indicated when the sulfate content increases to a higher level than the bicarbonate content, and the pH is on the acid side, below 5.5.

Oil field operations, when brine is encountered, are reflected by changes in sodium and chloride contents of the water. For Kentucky water, the influence is pronounced when either chloride or sodium exceeds 20 - 25 parts per million as an average value.

The four reporting stations for general water quality reflect different situations on the river.

The Munfordville Station is near the headwaters but below the Green River Reservoir with 18% of the drainage area of the basin. This station has wide fluctuations between average and maximum value (Figure F-5). This station shows water quality in excess of those for Kentucky water particularly the high levels of sodium-(potassium) and chlorides. This can be attributed to an oil boom in Green and Taylor Counties which produced 10 million barrels in 1959. However, the graph for last year's data (Figure F-4) indicates these levels have decreased to pre-oil field conditions due to the decrease in oil production and an increase in control measures.

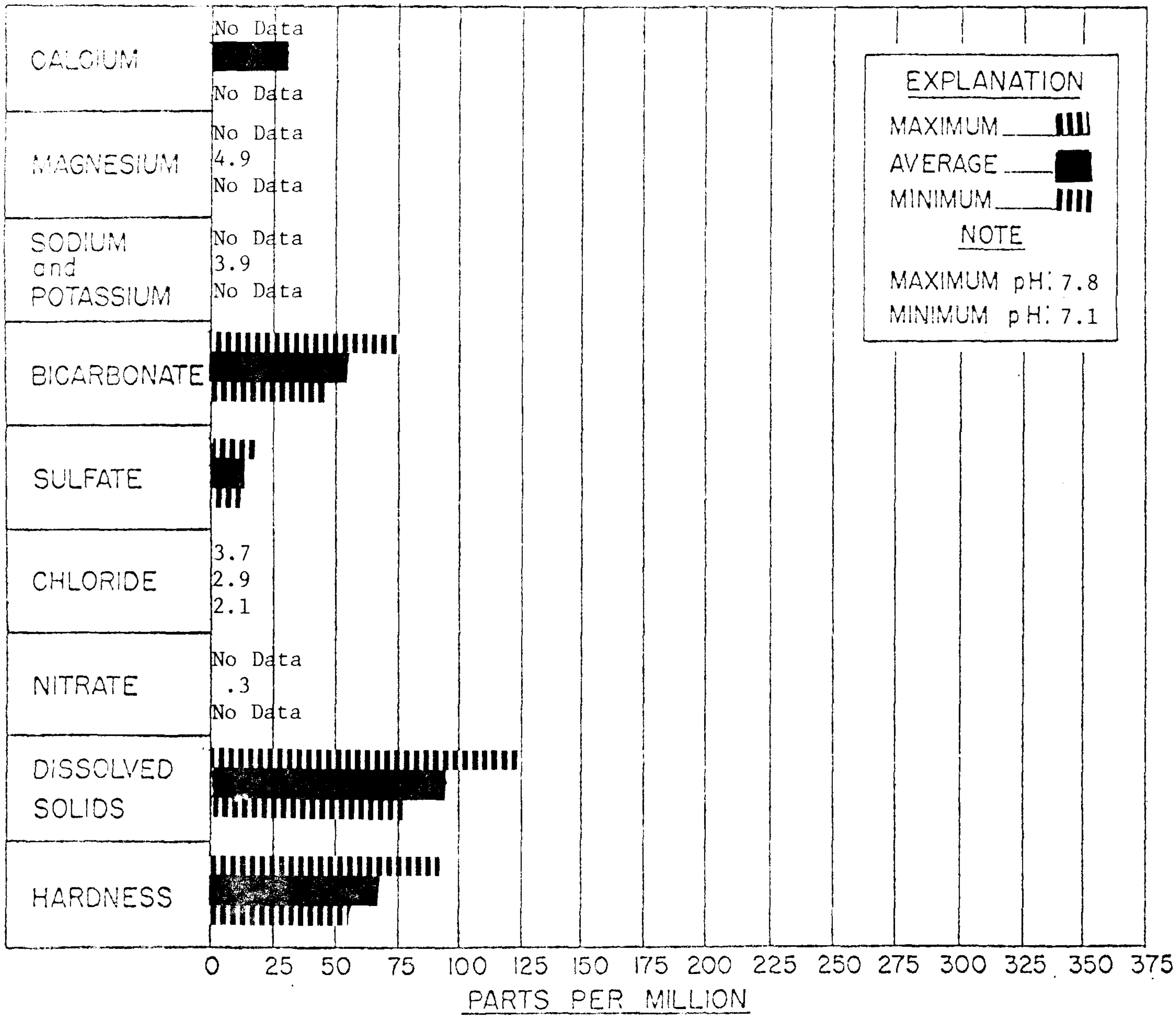
The station on the Barren River at Bowling Green has approximately the same size drainage basin area as the station at Munfordville but the station at Bowling Green shows a stable water quality which is attributed to the Barren

River Reservoir. The graph (Figure F-2) indicates that the natural water quality of the Barren River Basin is a bicarbonate type water with most mineralization (dissolved solids) in the form of calcium bicarbonate.

The Pond River at Sacramento was chosen to depict the influence of coal production on a small drainage basin. Every parameter except bicarbonate (Figure F-7) is high in the Pond River which demonstrates the effect of acid mine drainage on water quality. Bicarbonate is a measure of a stream's capacity to neutralize acids. Bicarbonate has been depleted by acid mine drainage and this effect is shown by an average pH value of 4.9 with a minimum value of 2.8. To meet the energy crisis coal production is expected to increase over three times the present rate in Kentucky. The effects of coal mining on the Pond River water quality emphasized the influence that a marked increase in coal mining in the Green River Basin can produce on the basin water quality.

The effect of energy related resource development is indicated by comparison (Figure F-8) of the Green River Station at Beech Grove (covering 99% of the basin) with the Barren River Station (Figure F-2). The decrease in dominance of the bicarbonate hardness over the sulfate hardness clearly illustrates the increasing influence of coal production on the Green River Basin. The relatively high levels of sodium-(potassium) and chlorides reflect the past influence of the oil production throughout the basin.

At this time, the chemical water quality in the Green River Basin is good, but the demand for coal could have disasterous and long lasting effects on the water quality in the portions of the Green River Basin downstream from these developments. The influence of coal production is long lasting because there is no effective means, known at this time, of treating or eliminating acid mine drainage on a large scale.



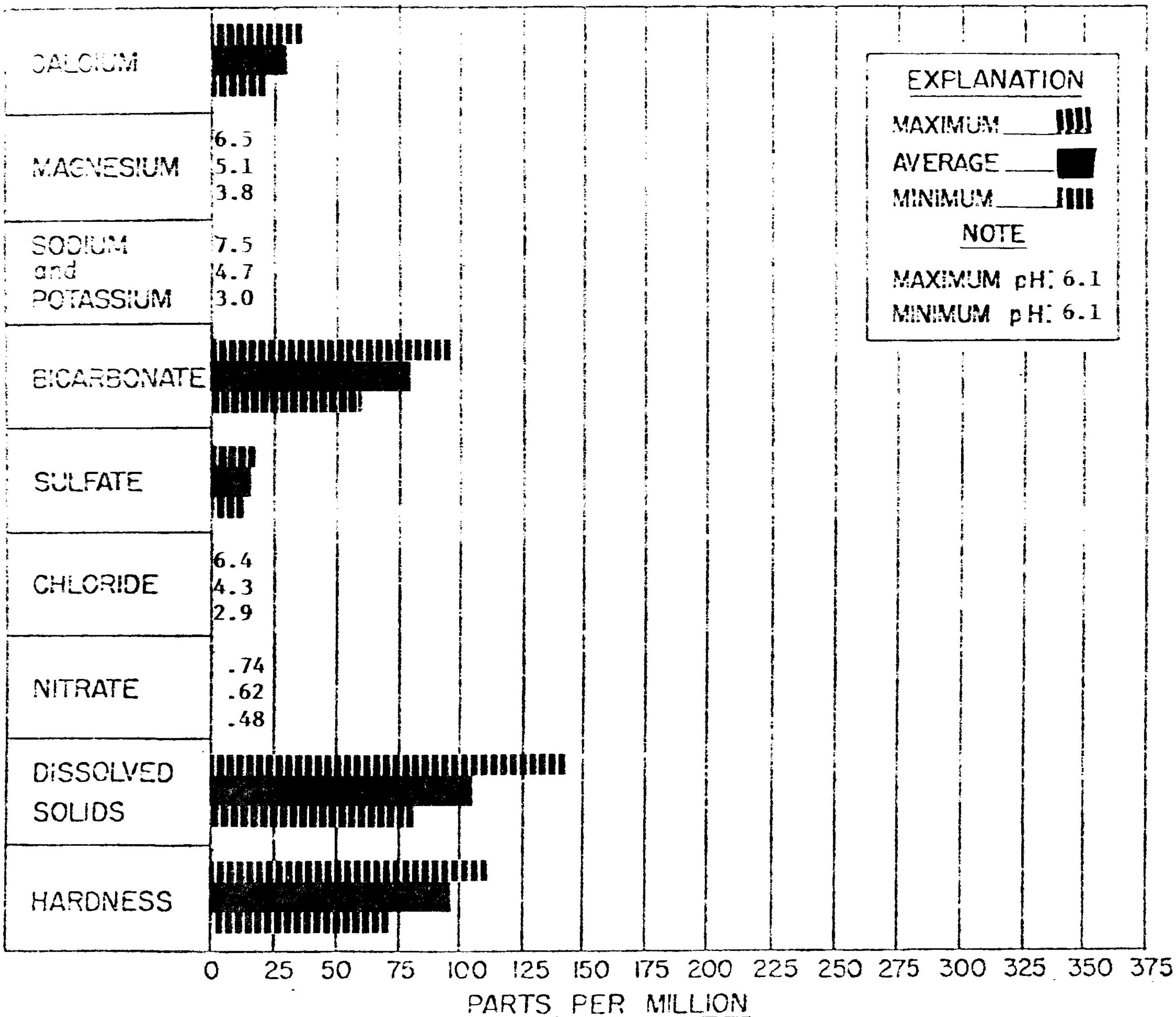
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE F-1

Green River

Greensburg

3-70 to 8-72



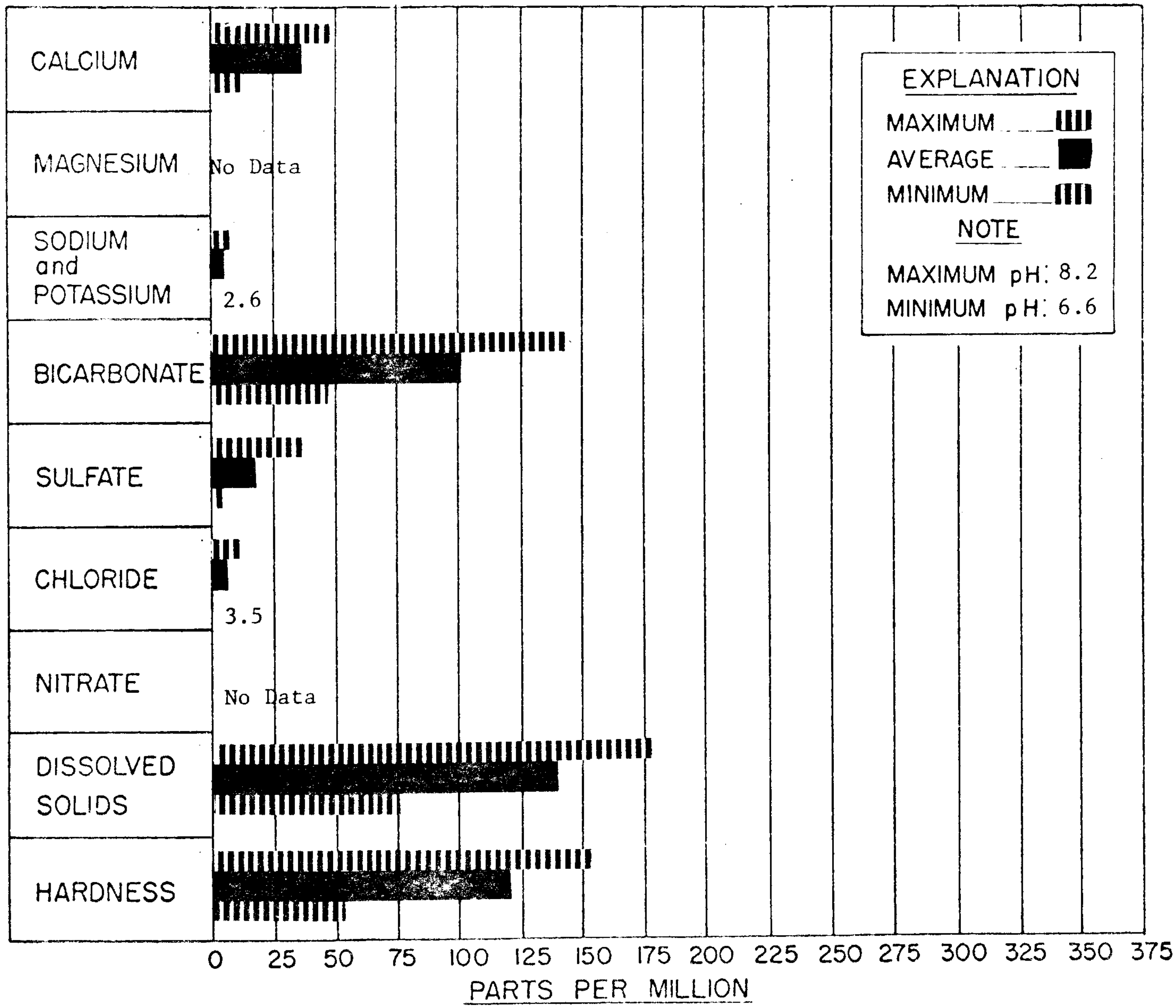
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE F-2

Barren River

Bowling Green

4-75 to 11-75



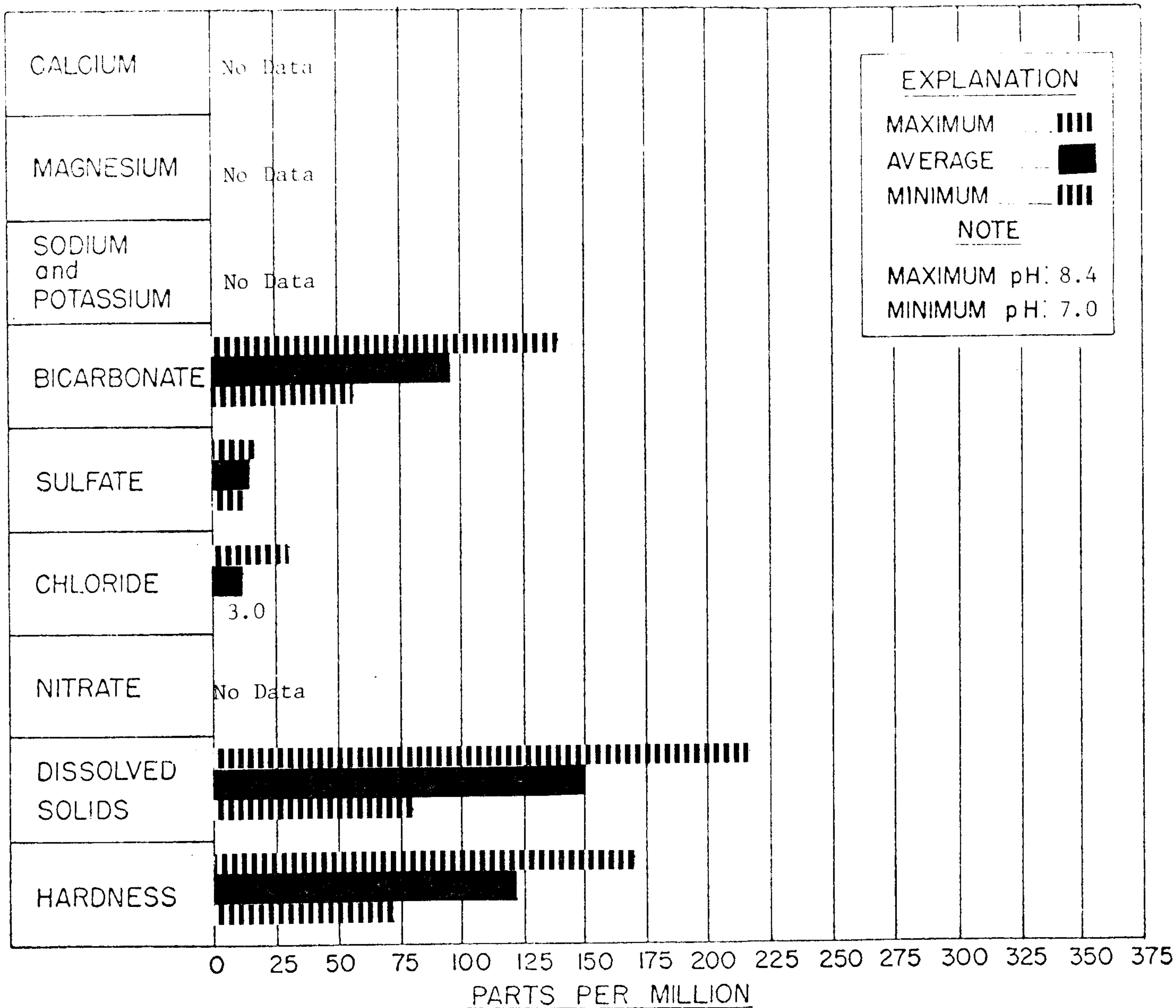
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE F-3

Barren River

Bowling Green

10-59 to 4-74



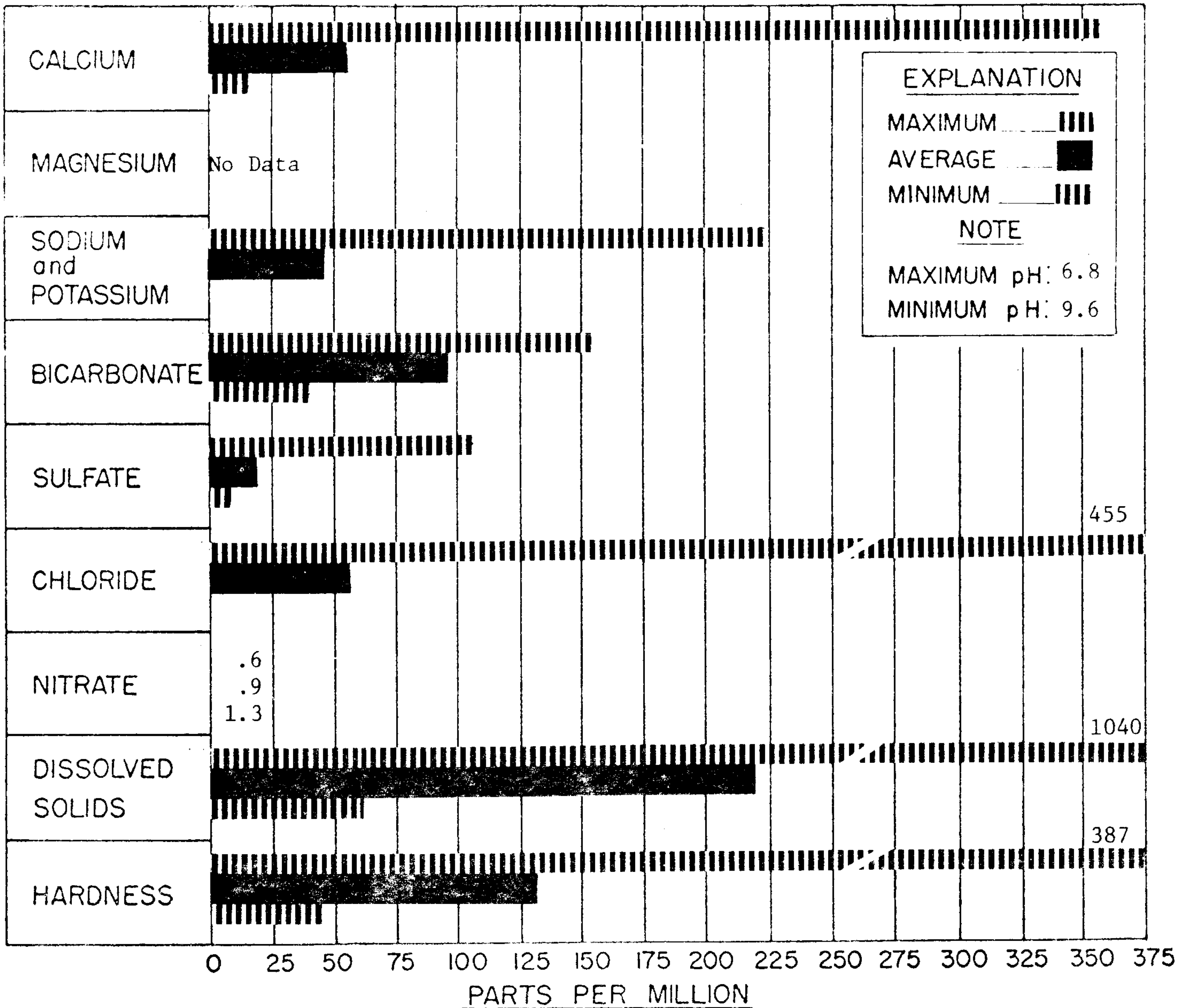
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE F-4

Green River

Munfordville

1-73 to 9-73



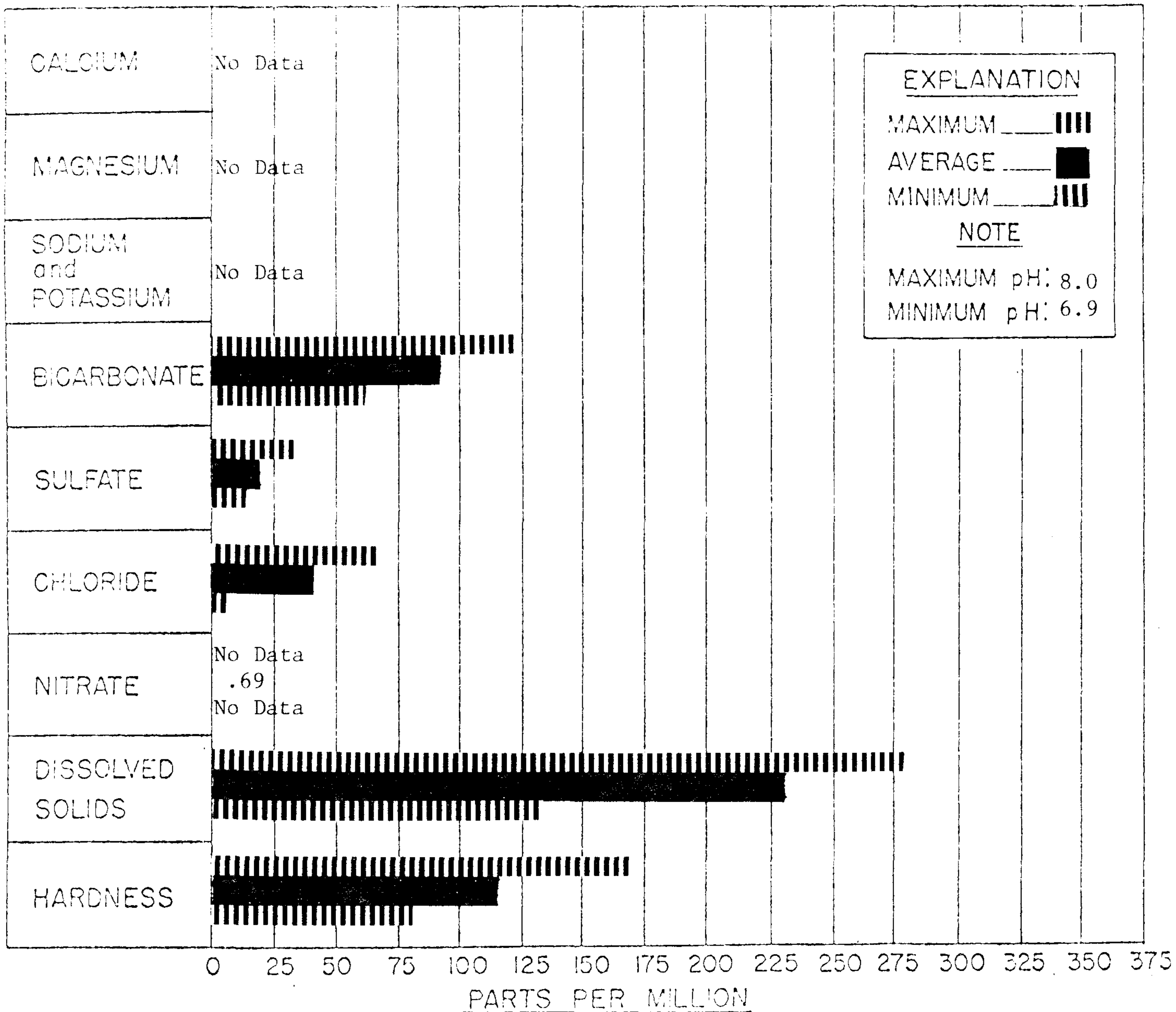
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE F-5

Green River

Munfordville

1-61 to 9-73



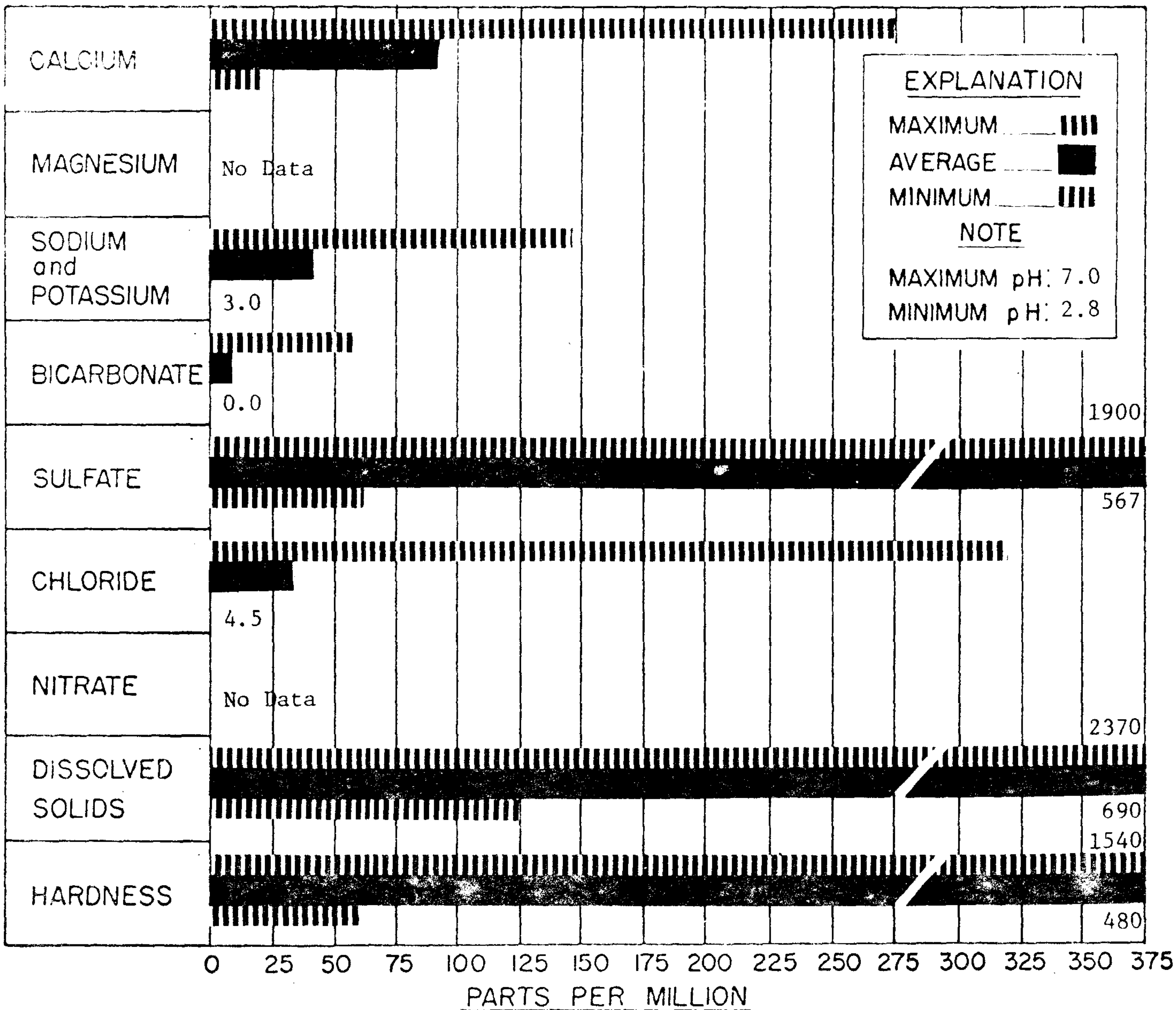
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE F-6

Pond River

Apex

4-61 to 8-72



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE F-7

Pond River

Sacremento

10-59 to 6-73

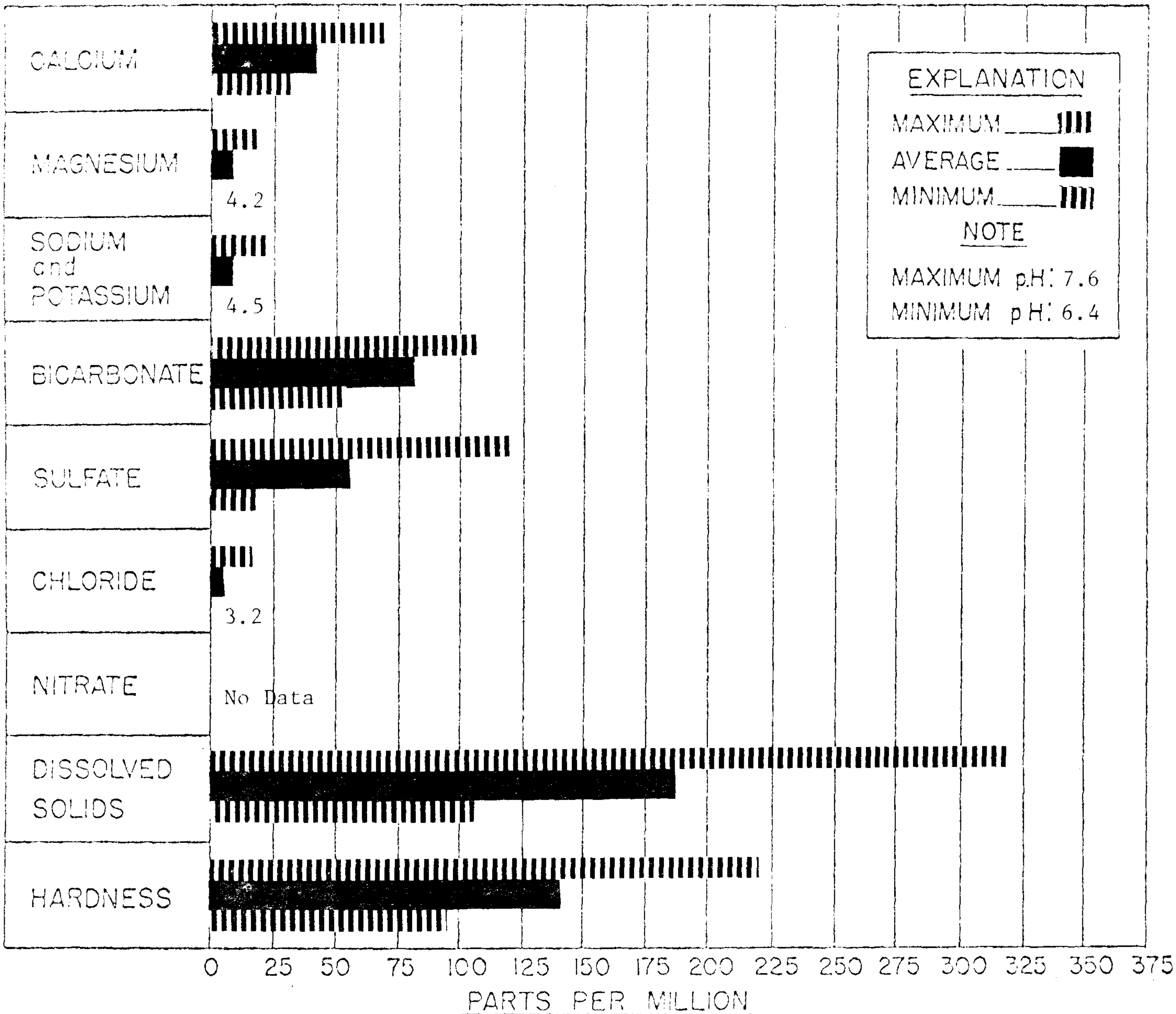


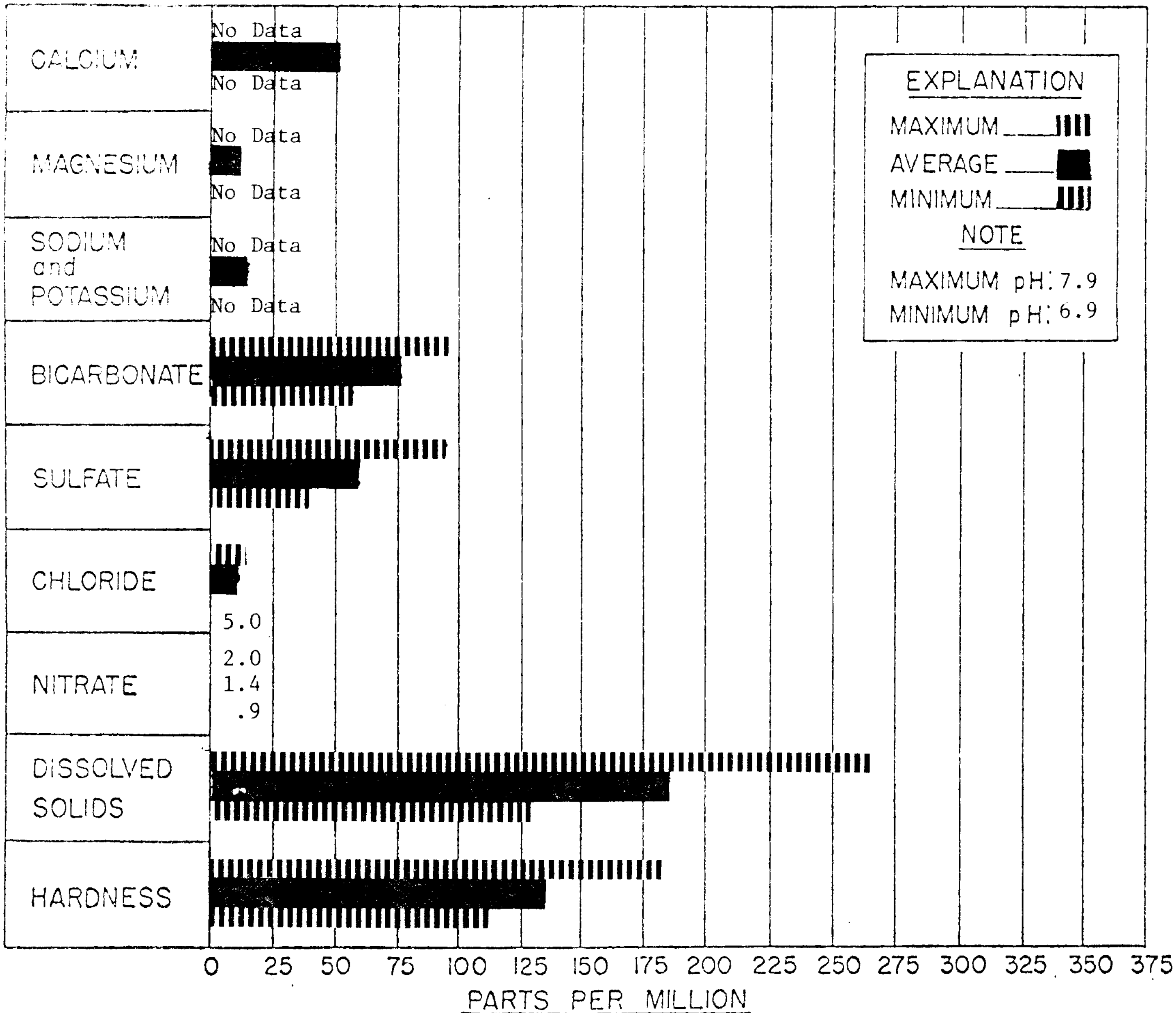
FIGURE F-8

Green River

Beech Grove

1-75 to 12-75

MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents



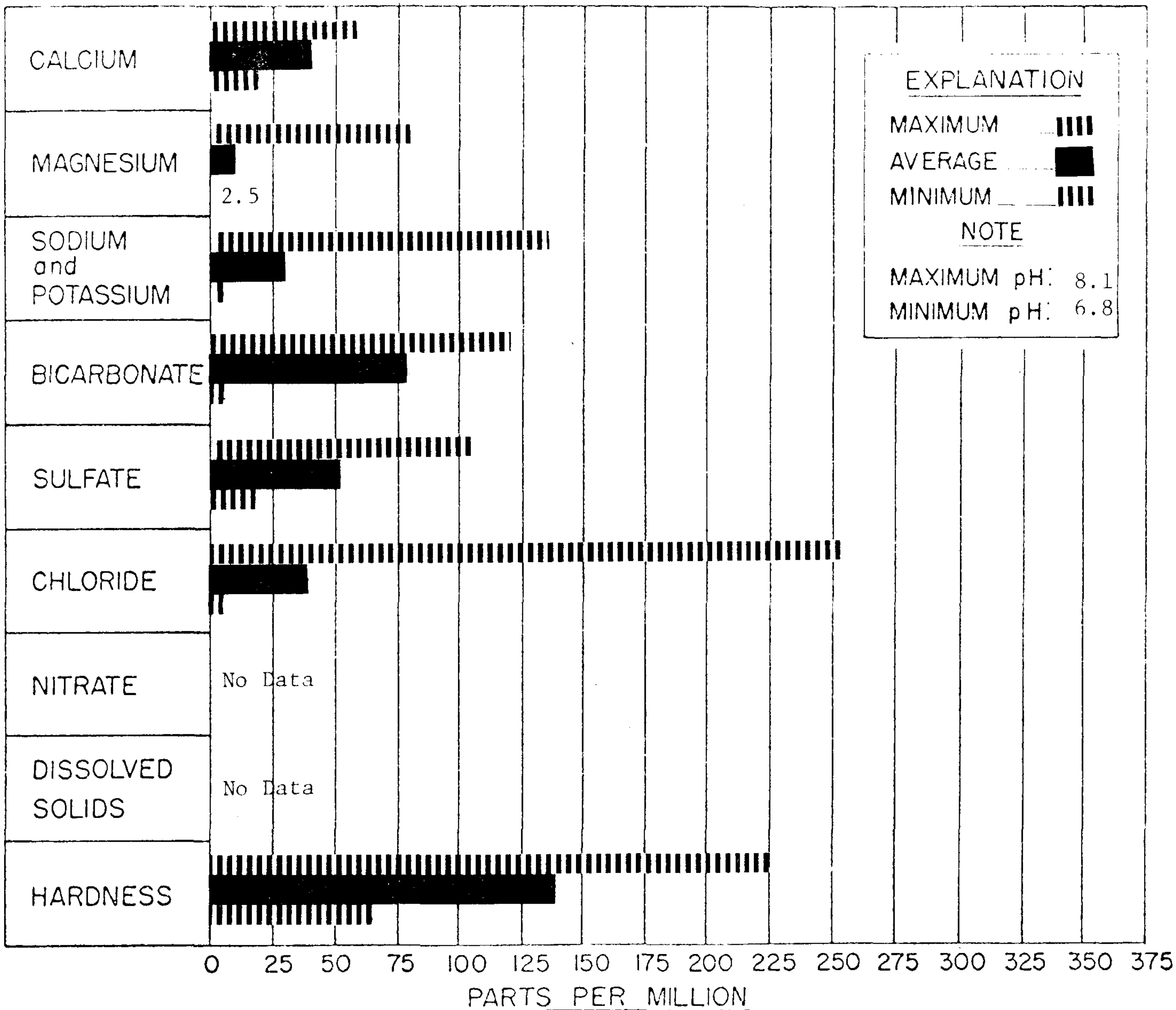
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE F-9

Green River

Lock 1

4-70 to 8-72



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE F-10

Green River

Lock No. 1

10-59 to 8-72

C. Trace Chemical Water Quality

Trace elements under 5.0 mg/l are separated from the general chemical background of this report because of their influence on human health. Generally, these materials are "heavy" metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State-Federal Water Quality Standards.

As a part of the monitoring strategy for Kentucky,"Special Surveys" will be undertaken to determine the causes of these levels.

D. Waste Load Affect on Water Quality

Biochemically degradable wastes impose a load on the dissolved oxygen recourses of a stream. Such waste loads are considered to have an adverse effect on water quality when they cause the dissolved oxygen (D.O.) concentration of the water to drop below the Kentucky Water Quality Standard of 5.0 mg/l. Approximately 1,670 miles of stream length were studied using a model to determine waste load allocation. The model was developed for the Kentucky Continuing Planning Process for River Basin Management Planning. Using this model it was determined that approximately 214 miles (12.8 percent) of the studied length would have a D.O. concentration of less than 5.0 mg/l. The design flow is equal to the ten year seven day low flow for this study, zero in many of the tributaries.

There were 214 miles of stream length affected, of which 172 miles (10.3 percent) will be affected by municipal discharges, 7 miles (0.4 percent) are affected by industrial discharges and 34 miles (2.1 percent) are affected by other discharges such as schools, trailer parks, subdivision, etc. These results are listed in Table F-11 in the Appendix.

E. Non-Point Source Effects

The major non-point sources in the Green River Basin are acid mine drainage, siltation, agricultural runoff, and storm drainage from large cities located near low flow streams. The acid mine drainage and much of the siltation is caused by the coal production which is located primarily in Muhlenberg, Hopkins and Ohio Counties. Small receiving streams affected by acid mine drainage cannot support permanent fish life, and water quality is deteriorated by major increases in hardness (calcium sulfate). A map showing the streams constantly affected by mining is included in the Appendix. Oil production (ten million barrels per year) in Kentucky results in some brine waste, the influence on water quality in the Green River Basin is revealed from the Water Quality graphs.

A Soil Conservation Service report indicates 18 million tons of sediment from erosion is entering the Green River stream system annually.

1. 53 percent of the sediment is produced by erosion from the basin's cropland.
2. 25 percent of the sediment is produced by gully erosion.
3. 12 percent of the sediment is produced by erosion from disturbed forest lands.
4. 10 percent of the sediment is produced from erosion on previously surface mined lands, newly disturbed surface mined lands, 1,600 miles of roadbank erosion and 600 miles of streambank erosion.

Siltation impact has been reduced by silt retaining structures, diversion ditches and terraces, but this phenomena will represent a significant problem until quick vegetative cover and good soil conservation practices are universally applied.

Storm water runoff from large cities could represent a significant non-point source where this runoff enters a stream with a small dilution ratio. The cities in the basin in this category are Glasgow, Elizabethtown and Madisonville.

F. Water Uses in the Basin

Water uses in the basin are public, industrial, recreational, fish and wildlife and agricultural.

Public water use consists of 18.6 million gallons per day, 14.7 million gallons per day of which is from surface water sources and 3.7 million gallons per day is from groundwater sources.

Industrial water usage consists of 10.5 million gallons per day, 9.8 million gallons per day which is from surface sources and 776,000 gallons per day is from groundwater sources. A complete table for public and industrial water usage (Table F-12) is included in the Appendix.

Approximately 96,000 acres of land and 35,000 acres of water are used for recreational purposes in the area. Four Corps of Engineers' developments account for 29,000 acres of water and 34,000 acres of adjacent land. In 1969, the attendance at the four reservoir areas was nearly 2.9 million visitor days, the Rough River had 1,162,500 visitor days, the Nolin River had 345,500, the Barren River had 875,200, and the Green River had 509,400 visitor days.

Other recreational opportunities exist on 2,600 acres of water in completed PL 566 United States Department of Agriculture, Soil Conservation Service watershed developments and about 3,400 acres of water in State, County, City and privately owned developments.

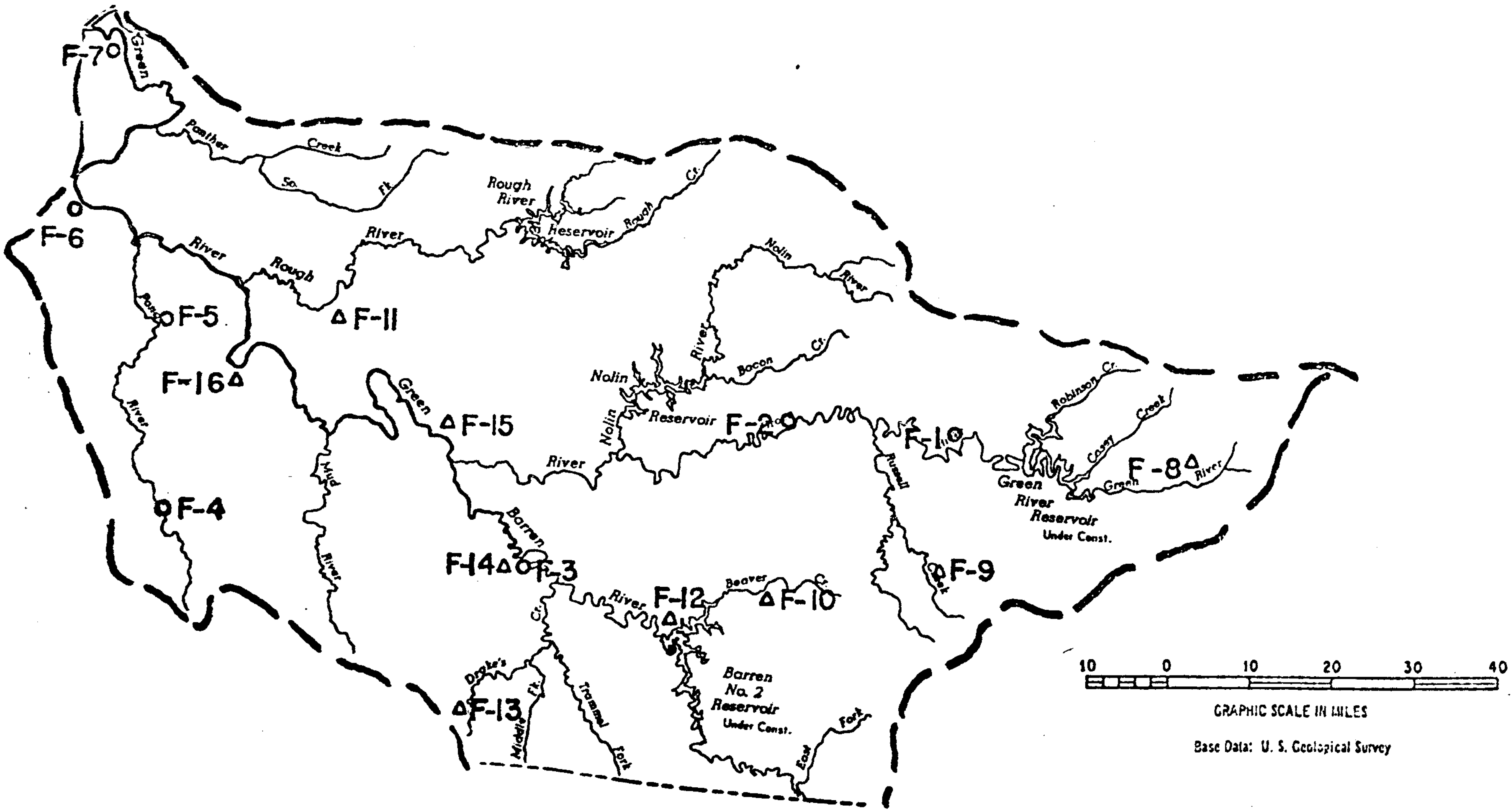
Habitat for aquatic wildlife and fishes in the basin is provided by 87 principal streams with a total length of 1,600 miles: four large Corps of Engineers' water impoundments; seven other lakes over 100 acres; and numerous smaller lakes and farm ponds. There are 190 species of fishes found in Kentucky and probably 75 percent of these can be found in the Green River Basin.

Generally, water in the basin is widely used in the agricultural industry, primarily for livestock watering with a small amount used for irrigation. In the Pond River sub-basin, water quality is sufficiently degraded so that it is not accepted for agricultural usage.

III. Summary

Water Quality in the Green River Basin is generally good. The water is slightly basic, hard, slightly salty and low in sulfates. Attention is needed, however, in the streams where coal is being produced. Since coal production is expected to increase dramatically, the influence on the rest of the basin is likely to become pronounced. Also, 21 municipal discharges need to be upgraded to meet a dissolved oxygen (D.O.) concentration of 5.0 mg/l during periods of low flow. The trace chemical water quality in the Green River Basin is good with the exception of the periodic high lead levels in the Green River at Munfordville and the high fluoride levels in the Pond River at Sacramento. The exact causes of these phenomena are not known at this time and further study is needed. Further study is also needed for the quality of storm water runoff leaving large cities and developed areas and entering small streams.

GREEN RIVER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Creek
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Rough River
Reservoir
Rough Cr.
River
Rough
Nolin River
Nolin Reservoir
Bacon Cr.
Green
River
Mud River
Barren River
Russell
Robinson Cr.
Casey Creek
Green River
Green River Reservoir
Under Const.
Beaver Cr.
Barren No. 2 Reservoir
Under Const.
Drake's
Middle Fk.
Trammel Fork
East Fork
10 0 10 20 30 40
GRAPHIC SCALE IN MILES
Base Data: U. S. Geological Survey

STATION KEY

F-1 GREEN RIVER AT GREENSBURG
F-2 GREEN RIVER AT MUNFORDVILLE
F-3 BARREN RIVER AT BOWLING GREEN
F-4 POND RIVER AT APEX
F-5 POND RIVER AT SACREMENTO
F-6 GREEN RIVER AT BEECH GROVE
F-7 GREEN RIVER AT LOCK I
F-8 GREEN RIVER AT LIBERTY
F-9 RUSSELL CREEK AT COLUMBIA
F-10 BEAVER CREEK AT GLASGOW
F-11 ROUGH RIVER AT HARTFORD
F-12 BARREN RIVER AT BARREN RESERVOIR
F-13 DRAKES CREEK AT FRANKLIN WPI
F-14 BARREN RIVER AT BOWLING GREEN WPI
F-15 GREEN RIVER AT MORGANTOWN WPI
F-16 GREEN RIVER AT CENTRAL CITY WPI

TABLE F-1

Drainage Areas in the Green River Basin

	COUNTY AREA (SQ.MI.)	PORTION OF COUNTY (SQ.MI.)	% OF COUNTY IN BASIN
Adair	393	353	90
Allen	364	364	100
Barren	486	486	100
Breckinridge	564	243	43
Butler	443	443	100
Casey	435	341	79
Christian	726	161	22
Daviess	462	378	82
Edmonson	304	304	100
Grayson	512	512	100
Green	282	282	100
Hancock	187	29	16
Hardin	616	400	65
Hart	425	425	100
Henderson	433	121	28
Hopkins	553	278	50
Larue	260	171	65
Lincoln	340	60	17
Logan	563	329	58
McLean	257	257	100
Metcalfe	296	258	87
Monroe	334	225	68
Muhlenberg	481	481	100
Ohio	596	596	100
Pulaski	654	0.1	0.1
Russell	238	67	28
Simpson	239	143	60
Taylor	284	284	100
Todd	376	137	37
Warren	546	546	100
Webster	339	141	42
Sub total	12,988.00	8,821	68
Tennessee Area		408	
Total Drainage Basin		9,229	

Source: Soil Conservation Service Type IV Draft river basin report for the Green River, 1975

Table F-2

Slopes of Streams in the Green River Basin

Sub-basin		Average Slope (feet/mile)	Drainage Area (mi^2)
Russell Creek		5.4	289
Little Barren River		7.7	282
Nolin River -	Upper Reaches	4.7	727
	Lower Reaches	2.5	
Barren River -	Upper Reaches	7.7	2,262
	Lower Reaches	1.0	
Mud River		3.0	375
Rough River		0.8	1,081
Pond River		1.9	799
Panther Creek		1.5	374
Green River -	Upper Reaches	6.6	9,229
	Lower Reaches	n/a	

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e river basin planning effort.

Table F-3

Locks and Dams in the Green River Basin

Lock and Dam	Mile	Length of Pool	Pool Elevation
1	9	54	349
2	63	45	363
3	108	36	380
4	145	23	396
5	168	14	411
6	182	18	421
Green River Reservoir	306		

Source: Kentucky Department for Natural Resources and Environmental Protection, Division of Water Resources

Table F-4

Coal Production by County and Type of Mining
in the Green River Basin

County	Strip	Underground	Auger	Total
	Coal Mining Methods (Tons)			
Butler	133,100	71,100	--	204,200
Christian	80,500	--	--	80,500
Daviess	1,012,400	--	--	1,012,400
Henderson	--	92,600	--	92,600
Hopkins	2,333,600	2,752,300	76,000	5,162,600
McLean	1,108,700	--	--	1,108,700
Muhlenberg	20,843,600	5,104,200	136,000	26,083,800
Ohio	4,899,500	1,535,800	--	6,435,300
Totals	30,411,400	9,556,000	212,700	40,180,100
Percent of Totals	75	24	1	100

Source - Annual Report of the Department of Mines and Minerals for Kentucky, 1973.

Table F-5

Allowable Bench Width in Strip Mining

Slope in Degrees	Maximum Bench Width
12° - 14°	220'
15° - 18°	170'
19° - 20°	155'
21°	140'
22°	130'
23°	120'
24°	110'
25°	100'
26°	90'
27°	80'
Auger Only	
28°	60'
29° - 30°	55'
31° - 33°	45'
33° + No Fill Bench	

Source: Kentucky Department for Natural Resources and Environmental Protection, Division of Reclamation

Table F-6

Oil Production by County for Selected Years in the Green River Basin

County	Year 1969	1970	1971	1972
	-Barrels-			
Adair	7,545	275,930	330,750	293,334
Allen	61,850	47,398	39,123	36,073
Barren	11,413	10,106	12,343	11,186
Breckinridge	5,248	5,648	7,766	7,666
Butler	62,124	54,290	47,008	59,827
Casey	12,698	11,872	7,325	5,274
Christian	40,223	38,735	38,293	33,737
Daviess	997,693	786,376	720,236	584,490
Edmonson	449	428	510	368
Grayson	---	---	---	---
Green	112,019	71,042	62,950	44,604
Hancock	11,990	11,426	11,341	10,230
Hardin	---	---	---	---
Hart	16,670	15,390	15,455	13,171
Henderson	555,931	477,206	397,706	328,492
Hopkins	427,640	396,358	414,692	354,246
Larue	---	---	---	---
Logan	746	1,496	741	391
McLean	686,140	584,665	551,354	558,665
Metcalfe	81,638	74,030	62,142	486,541
Monroe	15,447	15,006	12,536	10,955
Muhlenberg	405,689	346,307	300,467	253,187
Ohio	467,421	385,412	328,608	276,390
Pulaski	---	---	---	---
Russell	158	45	49	356
Simpson	2,303	6,744	7,074	6,033
Taylor	43	255	78	---
Todd	55	---	389	453
Warren	23,770	22,364	20,380	21,919
Webster	367,382	281,785	270,452	298,728

Source: Soil Conservation Service Type IV Draft River Report for the Green River, 1975

Table F-7

Lakes in the Green River Basin

Corps of Engineers Impoundments	Seasonal Capacity	Seasonal Area
Barren River Lake	190,280	10,000 AC
Rough River Lake	90,210	5,100 AC
Nolin Lake	170,200	5,790
Green River Lake	81,500	8,200
Total	532,190 AC-Ft.	29,090 AC

Other Impoundments Over 100 Acres	Capacity (AC-Ft.)	Area (AC)
Lake Herndon	2,265	147
Valley Creek MPS#4	1,830	160
Lake Malone	14,250	826
Shanty Hollow Lake	1,607	135
Big Muddy Creek F.R.S.#2	375	105
Mill Creek MPS#4	1,705	109
Mud River MPS#6A	3,218	240
Peabody Coal - New River Queen Slurry Dam	3,907	162
Peabody Coal - Alston Mine-Area VI Dam	1,180	50
Total	30,330 AC-Ft.	1,930 AC

Source: Kentucky Department for Natural Resources and Environmental Protection, Division of Water Resources

TABLE F-8

Population Distribution in the Green River Basin

COUNTY	1970 URBAN POPULATION**	TOTAL RURAL	TOTAL POPULATION* IN BASIN
Adair	3234	9803	12,100
Allen			12,600
Barren			28,700
Breckinridge	4235	10554	4,550
Butler			9,720
Casey	1765	11165	8,760
Christian	22665	33559	7,450
Daviess	51081	28405	24.000
Edmonson			8,750
Grayson			16,500
Green			10,400
Hancock	2857	4223	670
Hardin	26520	51901	45,800
Hart			14,000
Henderson	23856	12175	3,400
Hopkins	23637	14530	27,900
Larue	3114	7558	8,100
Lincoln	3748	12915	2,270
Logan	9240	7607	15,900
McLean			9,060
Metcalfe	958	7219	7,250
Monroe	2766	8876	8,760
Muhlenberg			27,500
Ohio			18,800
Pulaski			0
Russell	2668	7874	2,210
Simpson	6553	6501	10,500
Taylor	7598	6540	17,000
Todd	3308	7515	2,530
Warren			57,400
Webster	7865	5417	3,620
Total	150,000	276,000	426,000

* Approximate measurement ± 10 per cent based on U.S. Census Data

** U. S. Census Data

Table F-9

City Population and Facility Grant Status in the Green River Basin in Kentucky

County	City	Population	Project Type	Comments
Adair	Columbia	3,234	1	Active
Allen	Scottsville	3,584	1	Active
Barren	Cave City	1,818	1	Pending
	(Park City)	567	1	Pending
	Glasgow	11,301	3	Active
Breckinridge				
Butler	Morgantown	1,394	1	Active
Casey	Liberty	1,765	1	Active
Christian	Crofton	631	1	Active
Daviess	Whitesville	752	1	Active
Edmonson	Brownsville	542	None	Sewers/STP
Grayson	Caneyville	530	1	Active
	Leitchfield-	2,983	1	Active
	(Clarkson)	660	2	Pending
Green	Greensburg	1,990	None	Sewers/STP
Hancock				
Hardin	Sonora	390	None	No Sewers
	Elizabethtown	11,748	1	Active
Hart	(Munfordsville)	1,233	1	Pending
	(Horse Cave)	2,068	1	Pending
	Bonnieville	328	1	Pending
Henderson				
Hopkins	Madisonville-	15,332	1 & 2	Active
	(Earlington)	2,321	1 & 2	Active
	(Hanson)	378	None	No Sewers
	Morton's Gap	1,169	None	No Sewers
	Nortonville	699	1	Active
	White Plains	729	None	No Sewers

Table F-9
Continued

County	City	Population	Project Type	Comments
Larue	Upton	552	None	No Sewers
	Hodgenville	2,562	1	Active
Lincoln				
Logan	Russellville	6,456	1	Active
	Auburn	1,160	None	Sewers/STP
	Lewisburg	651	None	Sewers/STP
McLean	Calhoun	901	3	Active
	Sacramento	437	None	No Sewers
	Island	410	1	Active
	Livermore	1,594	1	Active
Metcalfe	Edmonton	958	1	Active
Monroe	Gamaliel	431	None	No Sewers
	Tompkinsville	2,207	1	Active
	Fountain Run W. D.	128	1	Active
Muhlenburg	Greenville-	3,875	1	Active
	(Central City)	5,450	1	Active
	(Powderly)	631	1	Active
	Drakesboro	907	1	Active
Ohio	Beaver Dam-	2,622	1	Active
	(Hartford)	1,868	1	Active
	(McHenry)	420	1	Active
	Fordsville	489	1	Active
	Centertown	323	None	No Sewers
	Rockport	377	None	No Sewers
Pulaski				
Russell				
Simpson	Franklin	6,533	1	Active
Taylor	Campbellsville	7,598	1 & 2	Active
Todd				
Warren	Smiths Grove	756	None	No Sewers
	Woodburn	351	None	No Sewers
	Bowling Green	36,253	1	Active

Table F-9
Continued

County	City	Population	Project Type	Comments
Webster	Slaughters	276	1	Active
	Sebree	1,092	None	Sewers/STP

NOTE: Project type is related to the grant process step applied for or active for each municipality. Step 1 is the preliminary studies (201 Facilities Plan) required before design of the facilities. Step 2 is the design phase of the project, and Step 3 is the construction of facilities for the collection and treatment of wastewaters.

The comments relate to the status of the grant. Active indicates the project is funded and underway. Pending indicates that application for a grant has been made and is pending approval. No sewers indicates that the municipality does not presently have a comprehensive sewer system. Sewers/STP indicates the municipality is now served by sewers and treatment facilities.

The source of this information was the 1970 U. S. Census and the FY 77 construction grants list for Kentucky.

Table F-10

Water Quality Data for Green River Basin

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
STORET #00400	pH Specific Units Ky. Std. 6 LT pH LT 9						
Green R., Greensburg	76/01/19	76/12/07	6.8	8.5	6.0	10	.734
	70/03/03	72/08/24	7.3	7.8	7.1	9	.250
	59/10/14	76/08/24	7.2	8.1	6.4	113	.317
Green R., Munfordville	70/01/10	73/09/12	7.7	8.4	6.8	90	.392
USGS 03308500	65/01/12	73/09/12	7.7	8.6	6.8	208	.366
	59/10/09	73/09/12	7.6	9.6	6.5	400	.405
Barren R., Bowling Green	75/06/03	75/06/03	6.1			1	
USGS 03314500	70/02/11	74/04/09	7.8	8.1	7.5	12	.241
	65/11/09	74/04/09	7.7	8.2	6.8	31	.330
	59/10/16	74/04/09	7.5	8.2	6.6	45	.396
Pond R., nr. Apex	70/09/25	72/08/17	7.5	8.0	7.0	3	.503
USGS 03320500	61/04/12	72/08/17	7.4	8.0	6.9	5	.439
Pond R. nr. Sacramento	70/03/03	73/07/16	4.8	7.0	3.3	14	1.45
USGS 03321100	65/02/05	73/07/16	4.4	7.0	2.8	32	1.34
	59/10/17	73/07/16	4.0	7.0	2.8	73	1.39
Green R., nr. Beech Grove	76/01/19	76/12/07	6.8	8.5	6.0	10	.734
USGS 03321230	75/01/07	76/12/07	7.0	8.5	6.0	22	.585
Green R. at Lock 1	70/04/14	72/08/16	7.5	7.9	6.9	10	.374
USGS 03321500	66/01/19	72/08/16	7.5	8.1	6.9	27	.306
	59/10/10	72/08/16	7.4	8.1	6.8	35	.317
STORET #00095	Conductivity Micromhos						
Green R., Greensburg	76/03/26	76/10/22	123.3	150.0	110.0	3	23.095
	70/01/21	75/11/20	151.4	280.0	120.0	19	37.125
	59/10/14	76/10/22	193.5	2570.0	72.0	141	227.320
Green R., Munfordville	70/01/10	73/09/12	270.9	553.0	133.0	90	103.1
	65/01/12	73/09/12	337.9	1380.0	47.0	217	192.2
	59/10/09	73/09/12	549.9	942.0	47.0	432	732.5

Table F-10
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
Barren R., Bowling Green	76/01/28	76/11/17	278.0	380.0	180.0	5	86.429
	70/02/11	75/11/12	237.6	298.0	145.0	25	36.016
	59/10/16	76/11/17	251.1	380.0	116.0	77	42.476
Pond R., nr. Apex	76/01/29	76/11/15	320.0	440.0	180.0	5	93.005
	70/09/25	75/11/11	352.4	483.0	207.0	5	128.095
	61/04/12	76/11/15	321.0	483.0	180.0	12	103.475
Pond R., nr. Sacramento	70/03/03	73/07/16	1108.5	2140.0	515.0	17	565.4
	65/02/05	73/07/16	1406.6	3230.0	143.0	41	881.9
	59/10/17	73/07/16	1169.1	3230.0	143.0	82	800.6
Green R., Beech Grove	76/01/19	76/12/07	316.7	450.0	230.0	12	61.288
	74/10/16	76/12/07	307.7	500.0	190.0	27	72.117
Green R. at Lock 1	70/01/26	72/08/16	294.9	402.0	237.0	18	47.4
	66/01/19	72/08/16	316.2	479.0	234.0	39	63.6
	59/10/10	72/08/16	378.3	1080.0	154.0	84	177.0
STORET #70300	Dissolved Solids mg/l Ky. Std. 500						
Green R., Greensburg	70/03/03	72/08/24	93.4	124.0	77.0	9	15.4
	65/01/20	72/08/24	110.1	496.0	58.0	50	60.3
	59/10/14	72/08/24	107.8	566.0	58.0	112	61.2
Green R., Munfordville	70/01/10	73/09/12	159.2	296.0	76.0	90	58.7
	65/01/12	73/09/12	195.7	768.0	61.0	215	104.8
	59/10/09	73/09/12	309.7	5830.0	61.0	422	430.3
Barren R., Bowing Green	76/04/21	76/11/17	189.7	213.0	148.0	3	36.172
	70/02/11	75/07/15	140.0	175.0	82.0	17	24.298
	59/10/16	76/11/17	147.0	213.0	82.0	51	24.603
Pond R. nr. Apex	70/09/25	72/08/17	230.0	278.0	138.0	3	79.7
Pond R. nr. Sacramento	70/03/03	73/07/16	957.7	2020.0	332.0	14	587.9
	60/02/05	73/07/16	1084.2	2960.0	128.0	31	754.9
	59/10/17	73/07/16	856.3	2960.0	128.0	72	665.0
Green R., Beech Grove	76/01/19	76/11/09	205.7	288.0	142.0	10	46.624
	74/10/16	75/12/08	184.1	319.0	104.0	15	58.257
	74/10/16	76/11/09	192.8	319.0	104.0	25	53.956

Table F-10
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
Green R., Lock 1	70/04/14	72/08/16	184.2	259.0	128.0	10	44.3
	66/01/19	72/08/16	195.9	298.0	128.0	27	44.6
	59/10/10	72/08/16	223.4	572.0	105.0	69	88.4
STORET #00410	Alkalinity mg/1						
Green R., Greensburg	70/03/03	72/08/24	53.8	75.0	43.0	9	9.8
	66/10/19	72/08/24	61.1	114.0	30.0	21	20.6
	59/10/14	72/08/24	60.7	114.0	30.0	35	17.5
Green R., Munfordville	70/01/10	73/09/12	90.7	141.0	40.0	90	27.8
	65/01/31	73/09/12	95.2	141.0	40.0	167	26.7
	59/10/09	73/09/12	95.5	153.0	40.0	220	25.3
Barren R., Bowling Green	76/04/21	76/11/17	134.0	155.0	107.0	3	24.556
	75/07/15	70/02/11	95.5	125.0	57.0	17	16.306
	59/10/16	76/11/17	102.8	155.0	46.0	45	20.166
Pond R., nr. Apex	70/09/25	72/08/17	106.3	124.0	74.0	3	28.0
	61/04/12	72/08/17	91.0	124.0	60.0	5	29.4
Pond R., nr. Sacramento	70/03/03	73/07/16	7.4	43.0	.00	14	12.2
	67/04/05	73/07/16	5.6	43.0	.00	25	10.9
	59/10/17	73/07/16	8.7	57.0	.00	50	12.7
Green R., Beech Grove	76/01/19	76/11/09	82.0	107.0	59.0	11	17.263
	74/10/16	76/11/09	82.2	107.0	52.0	26	16.555
Green R., Lock 1	70/04/14	72/08/16	75.9	94.0	57.0	10	12.8
	66/10/18	72/08/16	74.2	107.0	44.0	21	16.5
	59/10/31	72/08/16	79.1	119.0	44.0	39	17.7
STORET # 00900	Hardness (mg/1) Ky. Std., o-60 soft, 61-120 hard, 121-180 hard, over 180 very hard.						
Green R., Greensburg	70/03/03	72/08/24	67.9	92.0	55.0	9	10.9
	65/01/20	72/08/24	77.7	195.0	44.0	50	26.8
	59/10/14	72/08/24	78.9	358.0	35.0	103	37.5

Table F-10
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
Green R., Munfordville	70/01/10	73/09/12	110.4	170.0	59.0	90	33.4
	65/01/12	73/09/12	123.7	387.0	50.0	207	44.9
	59/10/09	73/09/12	95.5	153.0	40.0	220	25.3
Barren R., Bowling Green	76/04/21	76/11/17	160.0	190.0	130.0	3	30.000
	70/02/11	75/07/15	113.4	140.0	71.0	12	18.829
	59/10/16	76/11/17	122.5	190.0	52.0	53	22.915
Pond R., nr. Apex	70/09/25	72/08/17	135.7	170.0	90.0	3	41.2
	61/04/12	72/08/17	115.8	170.0	80.0	5	40.1
Pond R., nr. Sacramento	70/03/03	73/07/16	560.7	1200.0	220.0	13	324.0
	65/02/05	73/07/16	620.7	1540.0	58.0	31	403.0
	59/10/17	73/07/16	487.9	1540.0	58.0	67	369.9
Green R., Beech Grove	76/01/19	76/11/09	141.0	200.0	100.0	10	27.669
	74/10/16	76/11/09	140.2	220.0	95.0	25	31.836
Green R., Lock 1	70/04/14	72/08/16	133.1	180.0	110.0	10	23.7
	66/01/19	72/08/16	137.9	200.0	94.0	27	27.5
	59/10/10	72/08/16	137.2	225.0	64.0	72	34.3

STORET #00080 Color Platinum-Cobalt units EPA Std. 75 units

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
Green R., Greensburg	71/04/07	71/04/07	3.0			1	
	65/01/20	71/04/07	6.8	25.0	2.0	21	5.11
	59/10/14	7/04/07	11.6	130.0	1.0	82	15.8
Green R., Munfordville	70/11/01	72/10/15	1.7	5.0	.00	3	2.88
	65/01/12	72/10/15	9.9	50.0	.00	67	9.53
	59/10/09	72/10/15	9.2	55.0	.00	253	9.53
Barren R. at Bowling Green	71/03/15	71/03/15	.00			1	
	66/07/20	71/03/15	3.2	5.0	.00	5	2.16
	59/10/16	71/03/15	5.9	38.0	.00	17	8.49
Pond R., nr. Sacramento	70/12/01	73/07/16	4.0	5.0	2.0	3	1.73
	65/02/05	73/07/16	4.5	7.0	5.0	8	2.17
	59/10/17	73/07/16	7.0	56.0	55.0	46	10.8

Table F-10
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
Green R., Lock 1	71/04/27	71/04/27	3.0			1	
	66/07/22	71/04/27	6.8	17.0	3.0	5	5.76
	59/10/10	71/04/27	7.0	40.0	1.0	48	8.25
STORET #00930	Sodium No Standard						
Green R., Greensburg	71/04/07	71/04/07	2.20			1	
	65/11/09	71/04/07	11.3	108.0	2.2	13	29.1
	59/10/14	71/04/07	7.8	121.0	1.60	51	21.9
Green R., Munfordville	70/11/01	72/10/15	25.7	45.0	12.0	3	17.2
	68/11/25	72/10/15	48.0	84.0	12.0	5	33.0
	59/11/08	72/10/15	76.7	478.0	3.5	54	99.5
Barren R., Bowling Green	76/04/21	76/11/17	4.4	6.1	3.0	3	1.563
	71/03/15	75/07/15	2.8	4.6	1.5	7	1.053
	59/10/16	76/11/17	3.6	6.1	1.5	27	1.165
Pond R., nr. Sacramento	70/2/01	73/07/16	28.3	46.0	17.0	3	15.5
	59/10/17	73/07/16	39.1	139.0	5.4	38	31.3
Green R., Beech Grove	76/01/19	76/11/09	6.8	11.0	4.3	10	2.387
	74/10/16	76/11/09	6.5	15.0	3.0	25	2.878
Green R., Lock 1	71/04/27	71/04/27	12.0			1	
	66/07/22	71/04/27	12.1	18.0	6.8	5	4.59
	59/10/10	71/04/27	27.9	132.0	4.2	56	28.0
STORET #00935	Potassium mg/l No Standard						
Green R., Greensburg	71/04/07	71/04/07	1.7			1	
	65/11/09	71/04/07	1.7	3.4	.9	13	.728
	59/10/14	71/04/07	1.5	3.4	.4	51	.630
Green R., Munfordville	70/11/01	72/10/15	2.3	2.7	2.0	3	.361
	68/11/25	72/10/15	2.5	2.9	2.0	5	.370
	59/11/26	72/10/15	2.1	5.2	.8	21	.957
Barren R., Bowling Green	76/04/21	76/11/17	1.5	1.8	1.3	3	.252
	71/03/15	75/07/15	2.2	5.0	1.0	7	1.360
	59/10/16	76/11/17	1.6	5.0	0.5	27	.864

Table F-10
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
Pond R., nr. Sacramento	70/12/01	73/07/16	7.5	15.0	3.6	3	6.52
	66/09/08	73/07/16	6.4	15.0	3.6	7	3.91
	59/10/17	73/07/16	3.5	15.0	.9	38	2.52
Green R., Beech Grove	76/01/19	76/11/09	3.0	11.0	1.4	10	2.863
	74/10/16	76/11/09	2.6	11.0	1.4	25	1.980
Green R., Lock 1	71/04/27	72/04/27	2.4			1	
	66/07/22	72/04/27	2.2	2.9	1.6	5	.484
	59/10/10	71/04/27	1.9	4.1	.9	54	.738
STORET #00940	Chloride mg/l Prep. EPA Std. 250 mg/l						
Green R., Greensburg	70/03/03	72/08/24	2.9	3.7	2.1	9	.6
	65/01/20	72/08/24	8.1	212.0	1.0	50	29.5
	59/10/14	72/08/24	15.4	750.0	1.0	114	75.4
Green R., Munfordville	70/01/10	73/09/12	19.2	80.0	3.0	90	17.5
	65/01/12	73/09/12	37.1	350.0	3.0	217	48.6
	59/10/09	73/09/12	104.4	3250.0	3.0	425	241.6
Barren R., Bowling Green	76/04/21	76/11/17	8.2	12.0	5.2	3	3.459
	75/07/15	70/02/11	5.3	6.9	2.9	17	1.216
	59/10/16	76/11/17	6.7	12.0	2.9	53	2.019
Pond R., Apex	61/04/12	72/08/17	33.7	64.0	9.5	5	25.8
Pond R., nr. Sacramento	70/03/03	73/07/16	14.2	31.0	8.7	14	6.46
	65/02/05	73/07/16	16.5	46.0	4.5	31	9.54
	59/10/17	73/07/16	33.0	318.0	4.5	71	44.7
Green R., Beech Grove	76/01/19	76/11/09	6.6	13.0	3.0	10	3.398
	74/10/16	76/11/09	6.4	14.0	3.0	25	2.962
Green R., Lock 1	70/04/14	72/08/16	9.1	13.0	5.0	10	2.47
	66/01/19	72/08/16	12.5	28.0	5.0	27	5.75
	59/10/10	72/08/16	39.4	254.0	5.0	72	51.4
STORET #00945	Sulfate mg/l Prop. EPA Std 250 mg/l						

Table F-10
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
Green R., Greensburg	70/03/03	72/08/24	15.3	19.0	14.0	9	1.93
	65/01/20	72/08/24	17.0	46.0	12.0	50	5.45
	59/10/14	72/08/24	15.5	46.0	9.6	113	21.2
Green R., Munfordville	70/01/10	73/09/12	16.5	29.0	9.0	90	3.39
	65/01/12	73/09/12	18.1	35.0	9.0	207	4.72
	59/10/09	73/09/12	17.9	106.0	7.4	398	7.05
Barren R., Bowling Green	76/04/12	76/11/17	19.3	25.0	16.0	3	4.933
	70/02/11	75/07/15	17.8	30.0	10.0	17	4.931
	59/10/16	76/11/17	17.5	36.0	8.0	53	4.858
Pond R., nr. Apex	70/09/25	72/08/17	22.0	32.0	16.0	3	8.72
	61/04/12	72/08/17	20.2	32.0	16.0	5	6.65
Pond R., Sacramento	70/13/03	73/07/16	628.0	1400.0	200.0	14	401.1
	65/02/05	73/07/16	776.6	1900.0	139.0	31	551.4
	59/10/17	73/07/16	569.0	1900.0	62.0	72	491.3
Green R., Beech Grove	76/01/19	76/11/09	59.6	110.0	34.0	10	20.619
	74/10/16	76/11/09	56.7	120.0	16.0	25	28.469
Green R., Lock 4	70/04/14	72/08/16	59.6	93.0	34.0	10	19.8
	66/01/19	72/08/16	62.2	107.0	32.0	27	19.8
	59/10/10	72/08/16	51.1	107.0	17.0	72	21.5
STORET #00618	Nitrate mg/1 Prop.EPA Std. 10 mg/1						
Green R., Greensburg	72/07/20	72/08/24	.30			1	
	66/10/19	72/08/24	.44	1.0	.16	4	.379
	60/10/11	72/08/24	.43	1.0	.09	6	.360
Green R., Munfordville	71/11/26	73/09/12	.88	1.60	.40	46	.278
	61/04/12	73/09/12	.86	1.60	.34	47	.286
Barren R., Bowling Green	76/04/21	76/08/26	1.1	1.3	0.8	2	.325
	71/12/29	75/07/15	0.8	1.2	0.5	10	.220
	61/04/11	76/08/26	.7	1.3	0.1	15	.304
Pond R., nr. Apex	72/08/17	72/08/17	.69			1	
Pond R., nr. Sacremento	71/08/05	73/07/16	.42	.70	.18	7	.248
Green R., Lock 1	72/02/09	72/08/16	1.4	2.0	.9	3	.513

Table F-10
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
STORET #00950	Fluoride mg/l Ky. Std. 1.0 mg/l						
Green R., Greensburg	70/09/08	72/08/24	.075	.10	.00	4	.050
	65/11/09	72/08/24	.118	.50	.00	16	.155
	59/10/14	72/08/24	.147	.50	.00	55	.116
Green R., Munfordville	70/09/09	72/10/27	.142	.20	.10	7	.053
	68/11/25	72/10/27	.144	.20	.10	9	.053
	59/10/15	72/10/27	.183	.50	.10	36	.102
Barren R., Bowling Green	76/04/21	76/11/17	0.2	0.2	0.1	3	.058
	70/09/14	75/07/15	0.1	0.3	0.0	11	.089
	59/10/16	76/11/17	0.1	0.3	0.0	31	.079
Pond R., nr., Apex	70/09/25	72/08/17	.133	.20	.10	3	.058
	61/04/12	72/08/17	.120	.20	.10	5	.045
Pond R., nr. Sacramento	70/09/15	73/07/16	1.36	3.30	.50	7	.950
	65/10/13	73/07/16	1.60	3.30	.30	13	.976
	59/10/17	73/07/16	1.03	3.30	.00	44	.962
Green R., nr. Beech Grove	76/01/19	76/11/09	0.2	0.2	0.1	10	.048
	74/10/16	76/11/09	0.2	0.4	0.0	25	.082
Green R., Lock 1	70/09/15	72/08/16	.20	.50	.00	5	.187
	66/07/22	72/08/16	.20	.50	.00	9	.141
	59/10/10	72/08/16	.192	.50	.00	51	.084
STORET #00915	Calcium mg/l No Std.						
Green R., Greensburg	71/04/07	71/04/07				1	
	65/11/09	71/04/07	27.9	55.0	16.0	13	11.0
	59/10/14	71/04/07	23.2	55.0	9.6	51	8.74
Green R., Munfordville	70/01/10	73/09/12	19.2	80.0	3.0	90	17.5
	65/01/12	73/09/12	37.1	350.0	3.0	217	48.6
	59/10/09	73/09/12	104.4	3250.0	3.0	425	241.6
Barren R., Bowling Green	76/04/21	76/11/17	50.7	60.0	40.0	3	10.067
	71/03/15	75/07/15	30.1	35.0	22.0	7	4.914
	59/10/16	76/11/17	37.4	60.0	17.0	27	8.706
Pond R., nr. Sacramento	70/12/01	73/07/16	139.3	270.0	61.0	3	113.9
	66/09/08	73/07/16	172.1	270.0	61.0	7	76.1
	59/10/17	73/07/16	97.0	274.0	18.0	38	70.0

Table F-10
Continued

	Beg. Date	End Date	Mean	Max	Min.	#OBS	S
STORET #01030	Chromium micrograms/liter Ky. Std. 50 ug/l						
Green R., Greensburg	76/02/25	76/06/72	3.3	10.0	0.0	3	5.774
	76/07/18	76/06/22	3.0	10.0	0.0	6	4.690
Barren R., Bowling Green	76/01/28	76/11/17	1.4	7.0	0.0	5	3.130
	75/08/25	76/11/17	1.0	7.0	0.0	7	2.646
Pond R., nr. Apex	76/01/29	76/11/15	3.6	18.0	0.0	5	8.050
	75/08/28	76/11/11	2.6	18.0	0.0	7	6.803
Green R., Beech Grove	76/04/06	76/08/05	0.0	0.0	0.0	2	0.000
	74/10/16	76/08/05	0.3	1.0	0.0	7	0.488
STORET #01049	Lead micrograms/liter Ky. Std. 50 ug/l						
Green R., Greensburg	76/02/25	76/06/22	9.7	17.0	3.0	3	7.024
	60/11/07	76/06/22	1.1	18.0	0.5	50	3.697
Green R., Munfordville	65/01/10	65/09/17	.00	.00	.00	9	.00
	62/11/12	65/09/17	.00	.00	.00	29	.00
Barren R., Bowling Green	76/01/28	76/11/17	14.6	38.0	0.0	5	14.553
	75/08/25	76/11/17	12.4	38.0	0.0	7	13.088
Pond R., Nr. Apex	76/01/29	76/11/15	12.2	42.0	0.0	5	16.947
	75/08/28	76/11/15	9.6	42.0	0.0	7	14.650
Pond R., nr. Sacramento	62/10/31	64/08/05	.00	.00	.00	4	.00
Green R., Beech Grove	76/01/19	76/08/05	5.7	11.0	0.0	3	5.508
	74/10/16	76/08/05	4.4	11.0	0.0	8	4.241
STORET #01000	Arsenic Micrograms/liter Ky. Std. 50 ug/l						
Green R., Greensburg	76/02/25	76/06/22	0.7	1.0	0.0	3	0.577
	75/07/18	75/11/20	0.0	0.0	0.0	3	0.0
Green R., Munfordville	65/01/10	65/09/17	.00	.00	.00	9	.00
	62/11/12	65/09/17	.00	.00	.00	29	.00
Barren R., Bowling Green	76/01/28	76/11/17	0.2	1.0	0.0	5	0.447
	75/08/25	76/11/17	0.1	1.0	0.0	7	0.378
Pond R., nr. Apex	76/01/29	76/11/15	0.0	0.0	0.0	5	0.0
	75/08/28	76/11/15	0.0	0.0	0.0	7	0.0
Pond R., nr. Sacramento	62/10/31	64/08/05	.00	.00	.00	4	.00

Table F-10
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
Green R., Beech Grove	76/04/06	76/08/05	1.0	1.0	1.0	2	0.000
	74/10/16	76/08/05	0.4	1.0	0.0	7	0.535

Bacteriological Data

STORET #31503 Total Coliform colinies per 100 ml Ky. Std 1000/100 ml
STORET #31616 Fecal Coliform colinies per 100 ml

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
Green River, Liberty							
Total Coliform	75/01/06	75/12/04	169	488	0	14	
	74/03/25	75/12/04	235	600	0	28	
Fecal Coliform	75/01/06	75/02/18	27	65	11	4	
	74/10/25	75/03/18	78	238	11	8	
Green R., Greensburg							
Total Coliform	74/03/19	74/12/16	606	1157	137	15	
Fecal Coliform	74/10/25	74/12/02	35	54	19	3	
Russell Crk.,Columbia							
Total Coliform	75/01/06	75/12/19	5220	50400	97	20	
	74/03/25	75/12/19	356	1053	0	29	
Fecal Coliform	75/01/06	75/02/18	39	104	4	4	
	74/10/25	75/02/18	95	321	4	9	
Green River, Munfordsville							
Total Coliform	75/01/08	75/12/18	182	800	0	13	
	74/04/16	75/12/18	382	2000	0	29	
Fecal Coliform	75/01/06	75/02/18	17	50	5	4	
	74/01/06	75/02/18	25	66	5	7	
Rough River Hartford							
Total Coliform	75/01/08	75/12/18	1335	6550	0	11	
	74/04/16	75/12/18	1027	6550	0	22	
Fecal Coliform	75/01/24	75/12/18	1558	3900	139	5	

Table F-10
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
Beaver Cr., Glasgow							
Total Coliform	75/01/06	75/12/04	210	484	0	13	
	74/03/25	75/12/04	228	700	0	15	
Fecal Coliform	75/01/06	75/05/12	5	126	0	3	
Barren River below Barren R. Reservoir							
Total Coliform	75/01/25	75/12/04	14	60	0	12	
	74/03/25	75/02/18	103	1333	0	25	
Fecal Coliform	75/01/25	75/02/18	24	126	0	6	
Drakes Cr., Franklin WPI							
Total Coliform	75/01/07	75/12/17	1605	7800	98	11	
	74/04/15	75/12/17	2755	19700	0	21	
Fecal Coliform	75/10/22	75/11/25	1553	3033	73	2	
Barren R. Bowling Green WPI							
Total Coliform	75/01/07	75/12/17	262	800	5	12	
	74/04/15	75/12/17	1236	13100	5	22	
Fecal Coliform	75/10/22		344			1	
Green R. Morgantown WPI							
Total Coliform	75/01/08	75/12/15	310	933	16	12	
	74/04/16	75/12/15	707	3600	16	23	
Green R., Central City WPI							
Total Coliform	75/01/08	75/12/18	975	4167	0	12	
	74/05/14	75/12/18	4451	52000	0	20	
Fecal Coliform	75/07/22	75/12/18	511	1303	0	3	

Table F
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
Green R., nr. Beech Grove	76/01/19	76/12/07	141.3	420.0	18.0	12	110.918
	75/02/11	76/12/07	256.0	2200.0	18.0	23	445.201
Green R., Lock 1	71/04/27	71/04/27	51.0			1	
	66/07/22	71/04/27	44.2	52.0	27.0	5	10.2
	59/10/10	71/04/27	39.7	65.0	20.0	56	10.1
STORET #00925	Magnesium mg/l No Std.						
Green R., Greensburg	71/04/07	71/04/07	4.9			1	
	65/11/09	71/04/07	6.08	14.0	3.9	13	2.59
	59/10/14	71/04/07	6.05	43.0	1.70	51	5.75
Green R., Munfordville	70/11/01	72/10/15	8.83	12.0	6.8	3	2.78
	68/11/25	72/10/15	10.5	14.0	6.8	5	3.09
	59/10/09	72/10/15	11.7	80.0	2.5	143	10.3
Barren R., Bowling Green	76/04/21	76/11/17	8.3	9.8	6.9	3	1.450
	59/10/16	76/11/17	6.8	12.0	2.3	27	2.148
Pond R., nr. Sacramento	70/12/01	73/07/16	63.7	130.0	22.0	3	58.1
	66/09/08	73/07/16	97.3	158.0	22.0	7	48.5
	59/10/17	73/07/16	44.6	158.0	5.8	38	40.2
Green R., nr. Beech Grove	76/01/19	76/11/09	9.6	16.0	6.8	10	2.561
	74/10/16	76/11/09	9.3	17.0	4.2	25	2.048
Green R., Lock 1	71/04/27	71/04/27	12.0			1	
	66/07/22	71/04/27	11.9	16.0	6.3	5	3.51
	59/10/10	71/04/27	9.2	18.0	3.5	56	3.35
STORET #01025	Cadmium micrograms/liter Ky. Std. 100 ug/l						
Green R., Greensburg	76/02/25	76/06/22	4.7	7.0	2.0	3	2.517
	60/11/07	76/06/22	0.3	7.0	0.0	50	1.287
Green R., Munfordville	65/01/10	65/09/17	.00			9	
	62/11/12	65/09/17	.00			29	
Barren R., Bowling Green	76/01/28	76/11/17	1.8	4.0	0.0	5	1.789
	75/08/25	76/11/17	2.1	4.0	0.0	7	1.676
Pond R., nr. Apex	76/01/29	76/11/15	3.2	6.0	0.0	5	2.588
	75/08/28	76/11/15	3.0	6.0	0.0	7	
Pond R., nr. Sacremento	62/10/31	64/08/05	.00			1	

Table F
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
Green R., Beech Grove	76/01/19	76/08/05	2.7	3.0	2.0	3	0.577
	74/10/16	76/08/05	1.6	4.0	0.0	8	1.598
STORET #01056	Manganese micrograms/liter Prop. Ky. Std. 50 ug/l						
Green R., Greensburg	72/07/20	72/08/24	74.0	87.0	61.0	2	18.4
	59/10/14	72/08/24	158.9	410.0	.00	11	134.2
Barren R., Bowling Green	71/12/29	72/07/25	61.2	96.0	29.0	4	28.2
	59/10/16	72/07/25	301.9	2400.0	.00	13	641.1
Pond R., nr. Apex	61/10/05	61/10/05	330.0			1	
Pond R., nr. Sacramento	71/11/18	73/07/16	8839.9				
Green R., Beech Grove	76/01/19	76/08/05	160.0	190.0	140.0	3	26.458
	74/10/16	76/08/05	168.8	380.0	10.0	8	120.646
Green R., Lock 1	72/05/09	72/05/09	180.0			1	
STORET #01046	Iron micrograms/liter, Prop EPA Std. 300 ug/l						
Green R. Greensburg	72/07/20	72/08/24	125.0	150.0	100.0	2	35.4
	59/10/14	72/08/24	240.0	1100.0	80.0	14	266.4
Green R., Munfordville	65/01/02	66/09/24	54.0	330.0	.00	15	84.2
Barren R., Bowling Green	71/12/29	72/07/25	100.0	200.0	.00	4	95.2
	59/10/16	72/07/25	288.6	2400.0	.00	14	611.9
Pond R. nr. Apex	61/10/05	61/10/05	190.0			1	
Pond R., nr. Sacramento	71/11/18	73/07/16	1202.0	2200.0	570.0	5	745.8
	59/10/17	73/07/16	1076.4	3200.0	90.0	25	874.5
Green R., Beech Grove	76/01/19	76/08/05	70.0	140.0	30.0	3	60.828
	74/10/16	76/08/05	40.0	140.0	0.0	8	44.721
Green R., Lock 1	72/05/09	72/05/09	370.0			1	

Table F-11

Organic Loads Affecting Streams in the Green River Basin

Length of streams to which treated organic loads are discharged		1,670
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow with present treatment		214
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow due to with present treatment	Municipal Discharges	173
	Industrial Discharges	6.8
	Other Discharges	34.5

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e river basin planning effort. The values indicate the stream miles in which the dissolved oxygen is predicted to be less than 5 mg/l when the stream flow is less than the once in ten year seven day (Q 10-7) low flow.

Table F-12

Water Usage for Industry and the Public in the Green River Basin

County	City	Surface Public	Surface Industrial	Ground Public	Ground Industrial
Adair	Columbia	267,000	2,700		
Allen	Scottsville			456,000	114,000
Barren	Glasgow Res.	867,000			
	Glasgow Creek	1,300,000	229,000		
	Park City			40,000	
Breckinridge	Kingswood			15,000	
Butler	Morgantown	180,000			
	Rochester	27,700	300		
Casey	Liberty	116,000	38,800		
Christian					
Daviess	Whitesville			40,400	
Edmonson	Bee Spring			1,360	
	Edmonson C.W.D.	265,000			
	Brownsville			60,100	
	Mammoth Cave			73,600	
Grayson	Caneyville	22,300	500		
	Leitchfield			279,000	45,400
Green	Gabe	3,500	172,000		
	Greensburg	172,000	43,000		
	Nally Gibson		24,000		
Hancock					
Hardin	Elizabethtown			1,630,000	16,400
	Upton			45,000	5,000
Hart	Horse Cave			525,000	45,700
	Munfordsville	82,100	11,200		
Henderson	Anaconda Alum.		639,000		

Table F-12
Continued

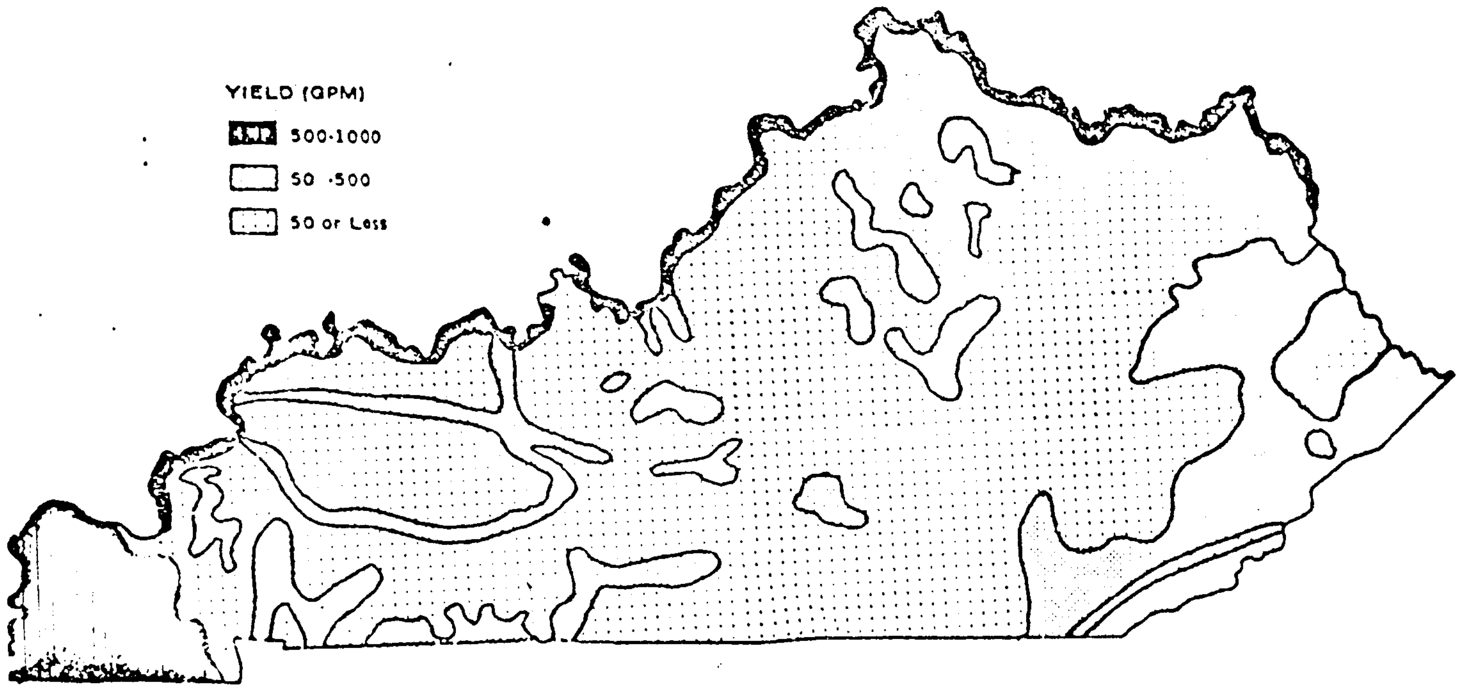
County	City	Surface Public	Surface Industrial	Ground Public	Ground Industrial
Hopkins	Earlington	148,000			
	Madisonville	1,790,000	268,000		
	Nortonville			75,600	3,900
	White Plains			17,100	900
	Cimmarron Coal		288,000		
	Island Creek Coal		39,800		
Larue	Hodgenville	190,000			
	Auburn Dyeing		12,700		
	Auburn			93,200	23,200
	Caldwell Lace		25,700		
	Lewisburg	43,300	4,800		
	Russellville	436,000	387,000	16,900	14,900
McLean	Calhoun	133,000	133,000		
	Livermore	128,000	14,200		
	Sacramento			19,750	
Metcalfe	Edmonton	48,800	5,400		
Monroe	Gamaliel Res and Creek	49,000			
	Tompkinsville	125,000	75,000		
Muhlenberg	Central City	713,000	75,000		
	Gilbrater Coal		1,520,000		
	Pittsburg Midway		164,000		
	Drakesboro			102,000	1,000
	Graham	17,100	175		
	Greenville	323,000	17,000		
	Kirkpatrick Mine		35,000		
	Wright Coal (Madisonville)		79,400		
	Peabody Coal (Beaver Dam)		739,000		
Ohio	Peabody Coal		469,000		
	Fordsville	48,000			
	Hartford	227,000	12,000		
	Ohio C.W.D.	310,000	77,500		
	Rockport	60,400			
	Peabody Coal (Hartford)		288,000		
	Peabody Coal		590,000		
Pulaski					
Russell					

Table F-12
Continued

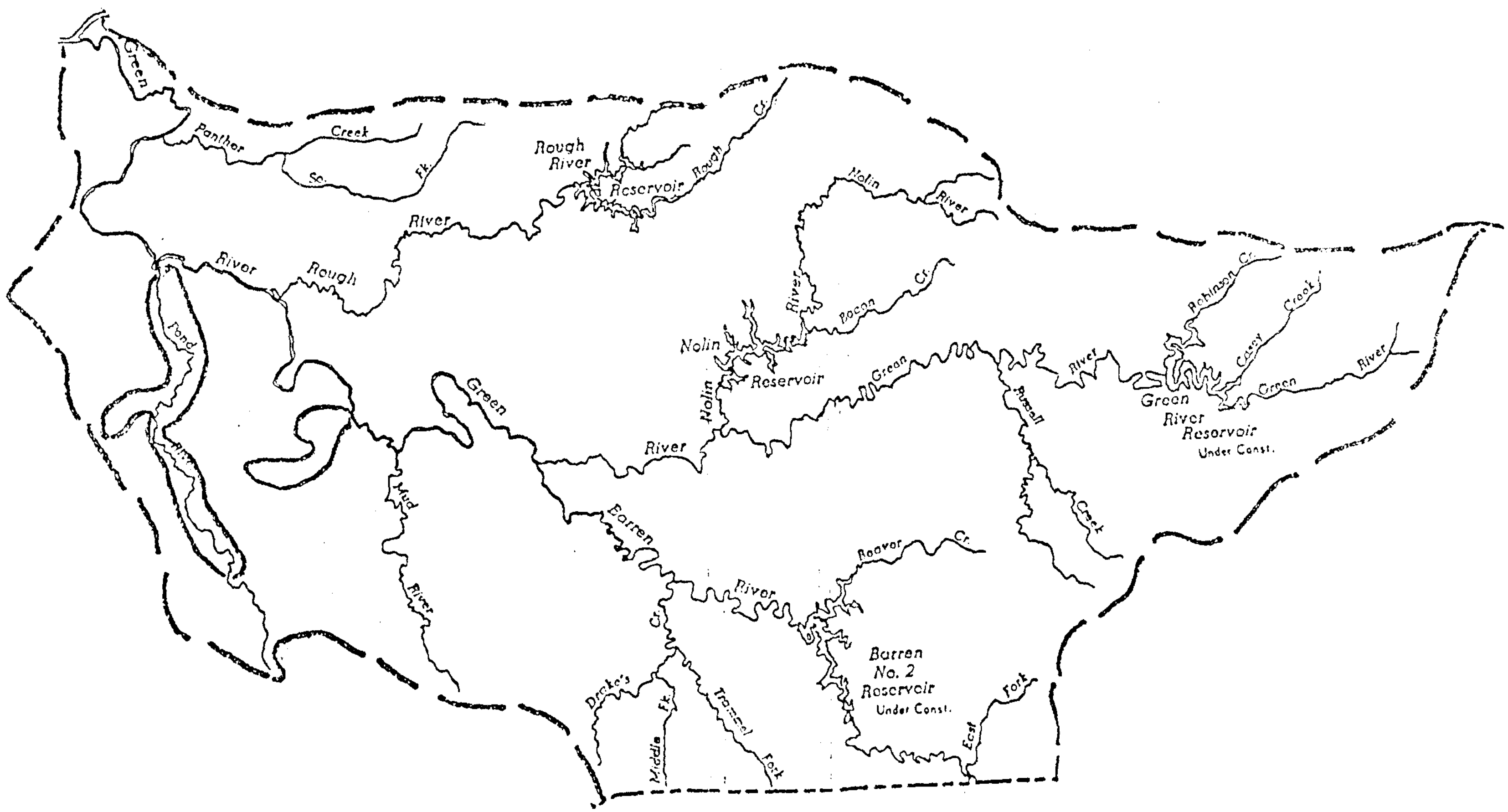
County	City	Surface Public	Surface Industrial	Ground Public	Ground Industrial
Simpson	Franklin	709,000	382,000		
Taylor	Campbellsville Res. and Creek	600,000	900,000		
	Tennessee Gas Piping		183,000	4,000	
Todd					
Warren	Bowling Green	5,230,000	922,000		
	Beech Bend			10,000	
	Warren C.W.D.			131,000	
	Pet Milk				460,000
	Smiths Grove			55,000	600
Webster	Dixon	65,000			
	Sebree			76,000	1,000
	Texas Gas (Slaughters)				44,500
	Slaughters	44,000			
		14,700,000	9,800,000	3,770,000	777,000

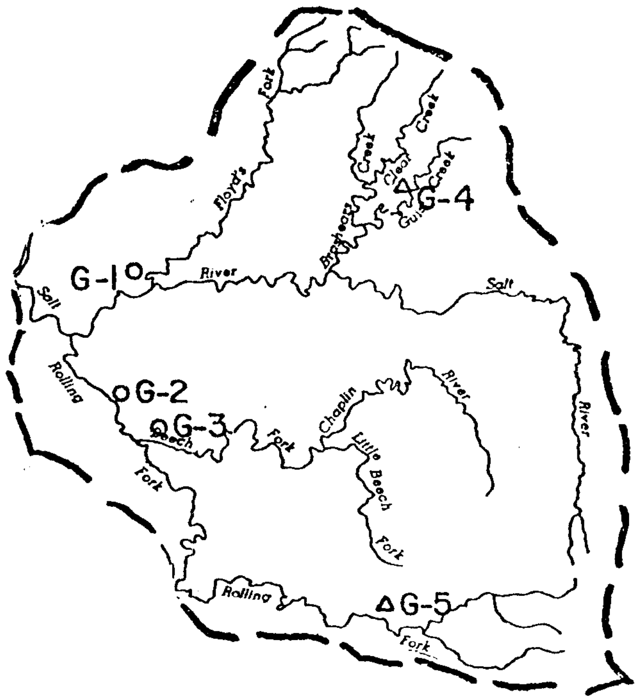
Source: Kentucky Department for Natural Resources and Environmental Protection
Division of Water Resources

Groundwater Availability in Kentucky

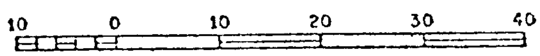


STREAMS CONTINUOUSLY AFFECTED by MINE DRAINAGE





SALT RIVER



GRAPHIC SCALE IN MILES

Base Data: U. S. Geological Survey

THE SALT RIVER BASIN

The Salt River Basin is the most centrally located basin in Kentucky. It extends 70 miles into Kentucky through rolling farmland and is as wide as it is long. The water quality in this basin is influenced by dry season low flow, excessive erosion, and by the largest population center in Kentucky, Louisville, being partly located within this basin.

The first section of this report will provide a basin description covering both physical and population characteristics. The second section will analyze the water quality considering its causes and effects.

I. Basin Description

A. Geography

The Salt River flows into the Ohio River 352 miles above the mouth of of the Ohio River. The city of West Point at the mouth of the Salt River is 23 miles downstream of Louisville.

The Salt River drains 2,932 square miles of rolling farmland in central Kentucky. This drainage basin contains all or part of the following counties: Bullitt, Jefferson, Oldham, Henry, Shelby, Anderson, Mercer, Boyle, Casey, Marion, Taylor, Larue, Hardin, Nelson, Washington, and Spencer. In the Salt River Basin, there are five sub-basins with an area over 200 square miles. Beech Fork has approximately 750 square miles, Brashears Creek, Floyds Fork, and the Chaplin River all drain about 270 square miles, and the Rolling Fork drains 145 square miles.

B. Topography

The basin lies wholly within the Bluegrass Region which has a hilly to gently rolling topography from east to west with an area of "Knobs" in the northwestern section around the Fort Knox military reservation. This basin is drained by three major streams. These are the Salt River, the Rolling Fork and Beach Fork. The slope of the Salt River is 5.0 feet per mile (ft./mi.).

The slope of Rolling Fork averages 6 ft./mi. and the slope of the Beach Fork is 4 ft./mi.

The average slope of the major tributaries are Brashears Creek, 6 ft./mi., Chaplin River, 6.5 ft./mi., and Floyds Fork, 7 ft./mi. The elevation in this basin varies from 380 to 1,140 feet above sea level.

Slope, up to ten ft./mi., has a direct effect on the reaeration of a stream. With slopes from 0-2 ft./mi., the reaeration is low. Slopes from 3-6 ft./mi. give a medium reaeration while slopes of 7-10 ft./mi. give a high reaeration. These stream slopes provide moderate to good reaeration of the streams.

C. Geology

The base parent materials in this basin are limestone and dolomite, slate and shale. The limestone and dolomite through solution impart hardness to water and give rise to a bicarbonate type of hardness.

The groundwater availability in the Salt River Basin is low. Wells which yeild 100 gallons per minute (g.p.m.) are rare, the majority of the wells produce 50 g.p.m. or less. This limited availability of groundwater and the "Knob" topography are factors causing extremely low flow during the dry months of the year.

D. Hydrology

The stream flow in the Salt River Basin was selected at four gauging stations. The stations are (1) at Boston on the Rolling Fork, (2) at Bardstown on the Beach Fork, (3) Fisherville on Floyds Fork, and (4) at Shepherdsville on the Salt River.

For these stations, the period of record, drainage area, average flow, maximum flow, minimum flow, and the seven day ten year low flows are shown in Table G-6.

Presently, there are no major impoundages in the Salt River to provide for low flow augmentation. The Corps of Engineers has been authorized to construct the Taylorsville Reservoir which will provide low flow augmentation of 60 cfs.

The Salt River at Shepherdsville is very flashy as shown in comparison of the average flow to the maximum. The ratio of average to maximum is 52. Most of the streams at some time of the year have zero flow. The low flow contributes to problems with organic waste loads and sediment.

E. Population

There are 507,232 people in this basin (see Table G-2). The SMSA of Louisville accounts for sixty-four per cent of the population. This portion of Louisville (Jefferson County) is located in the Pond Creek and Floyds Fork Sub-basins. Louisville has completed a 201 Facility Plan and is developing a 208 area wide waste water management plan. As the 201 plan is implemented, the effect of the 250 discharge into Pond Creek and Floyds Fork will be eliminated with the initial interceptors planned for completion in 1977 and all discharges eliminated by 1985. Roughly seven per cent of the population is located in Hardin County at Fort Knox. The rest of the population is located in small towns and rural populaton throughout the basin. There are eight towns (13,679 people who do not have sewers and these represent possible sources of pollution from septic tanks and other inadequate treatment devices.

TABLE G-6

SURFACE WATER RECORDS FOR THE SALT RIVER BASIN

STATION	PERIOD OF RECORD	DRAINAGE AREA	AVERAGE FLOW	MAXIMUM FLOW	MINIMUM FLOW	7-day/10-yr. LOW FLOW
Salt River at Shepherdsville	38 yr.	1,197 sq.mi.	1,551 cfs, 1.3cfs*/sq.mi.	78,200 cfs, 65cfs/sq.mi.	0 cfs	0.6 cfs
	wtr/yr 1976		1,552 cfs, 1.3cfs/sq.mi.	30,100 cfs, 25cfs/sq.mi.	11 cfs, 0.0cfs/sq.mi.	
Floyds Fork at Fisherville	32 yr.	138 sq.mi.	173 cfs, 1.3cfs/sq.mi.	28,500 cfs, 206cf/q.mi.	0 cfs	0 cfs
	wtr/yr 1976		173 cfs, 1.3cfs/sq.mi.	8,080 cfs, 59cfs/sq.mi.	1.0 cfs, 0.0cfs/sq.mi.	
Rolling Fork near Boston	38 yr	1,299 sq.mi.	1,752 cfs, 1.3cfs/sq.mi.	50,500 cfs, 39cfs/sq.mi.	0.4 cfs, 0.0cfs/sq.mi.	1.7 cfs
	wtr/yr 1976		1,933 cfs, 1.5cfs/sq.mi.	32,800 cfs, 25cfs/sq.mi.	32 cfs, 0.0cfs/sq.mi.	
Beech Fork at Bardstown	wtr/yr 1976**	669 sq.mi.		27,100 cfs, 41cfs/sq.mi.		0.2 cfs

* Cubic feet per second

** Operated as a continuous-record gaging station 1939-74, and as a crest-stage partial-record station since 1975.

NOTE: Data is taken from "Surface Water Records in Kentucky" by the United States Geological Survey. The 7-day/10-yr. low flow was taken from the waste load allocation produced as a component of the 303e River Basin Continuing Planning Process.

II. Basin Water Quality

In this section of the report the actual water quality in the Salt River Basin will be examined, along with some of the major factors involved. The major water uses in the basin are also presented.

A. A Description of Sampling Stations

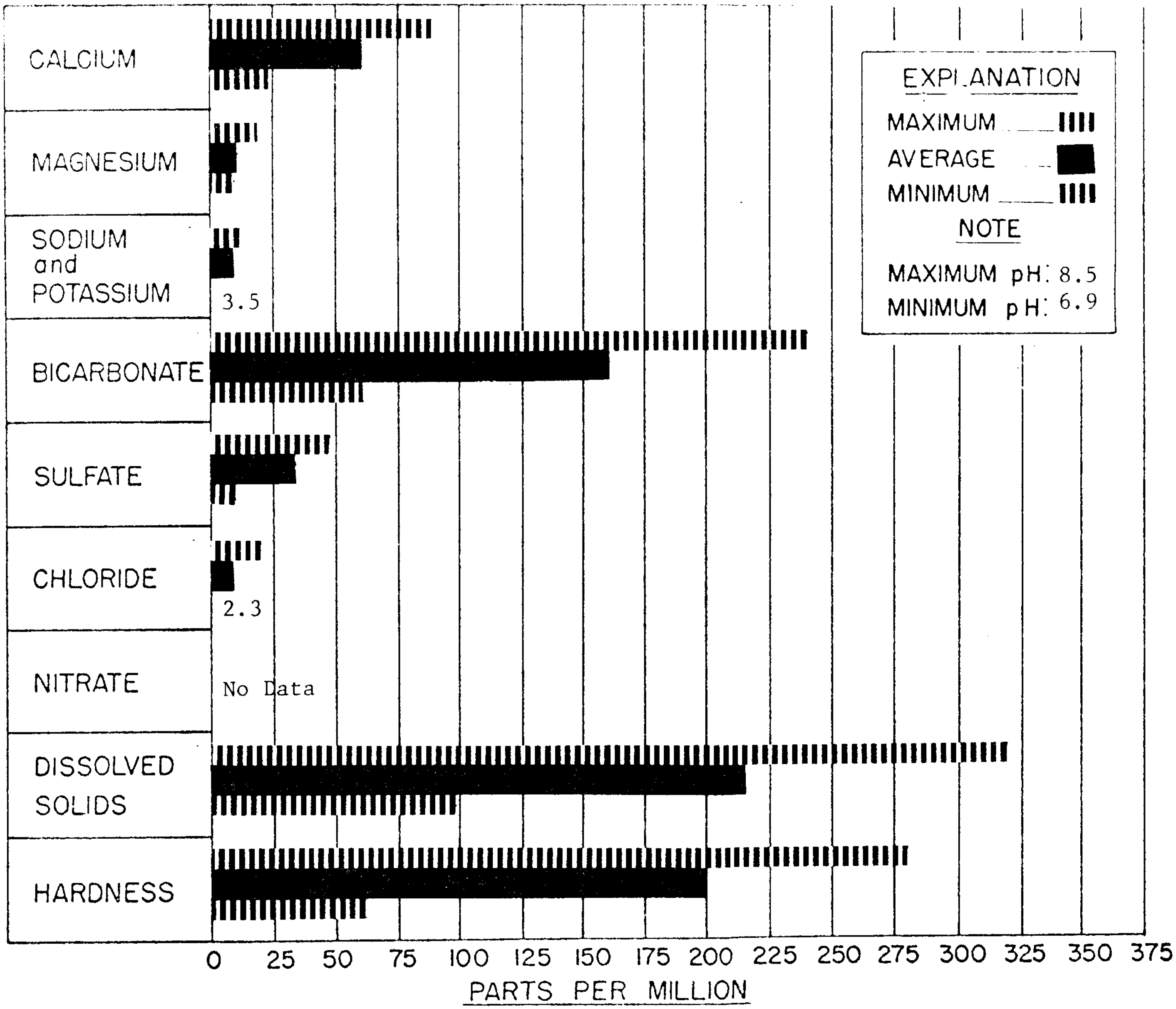
There is one station in this basin with sufficient data to describe water quality. It is located at Shepherdsville, Kentucky, 23 miles upstream from the mouth of the Salt River with drainage basin area of 1,200 sq. mi. or 41 per cent of the basin.

This station was chosen due to the location and length of record. It is believed that the water quality measured at this station is representative of the water quality in most of the surface streams in the basin.

B. General Chemical Water Quality

The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The chemical characteristics of a stream when viewed over a long period of time is primarily from surface water. The type of rock formation and soils which the surface water contacts causes this predominate chemical characteristic. The contribution of groundwater, which is generally higher in dissolved solids than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky is one of moderate hardness caused by calcium and magnesium salts.

In the Salt River Basin, there is a high bicarbonate ion content giving the water a high bicarbonate hardness. This is due to the limestone bedrock of the area. In all other respects the quality of the surface water is considered to be excellent. The graph of water quality indicates the variation from the



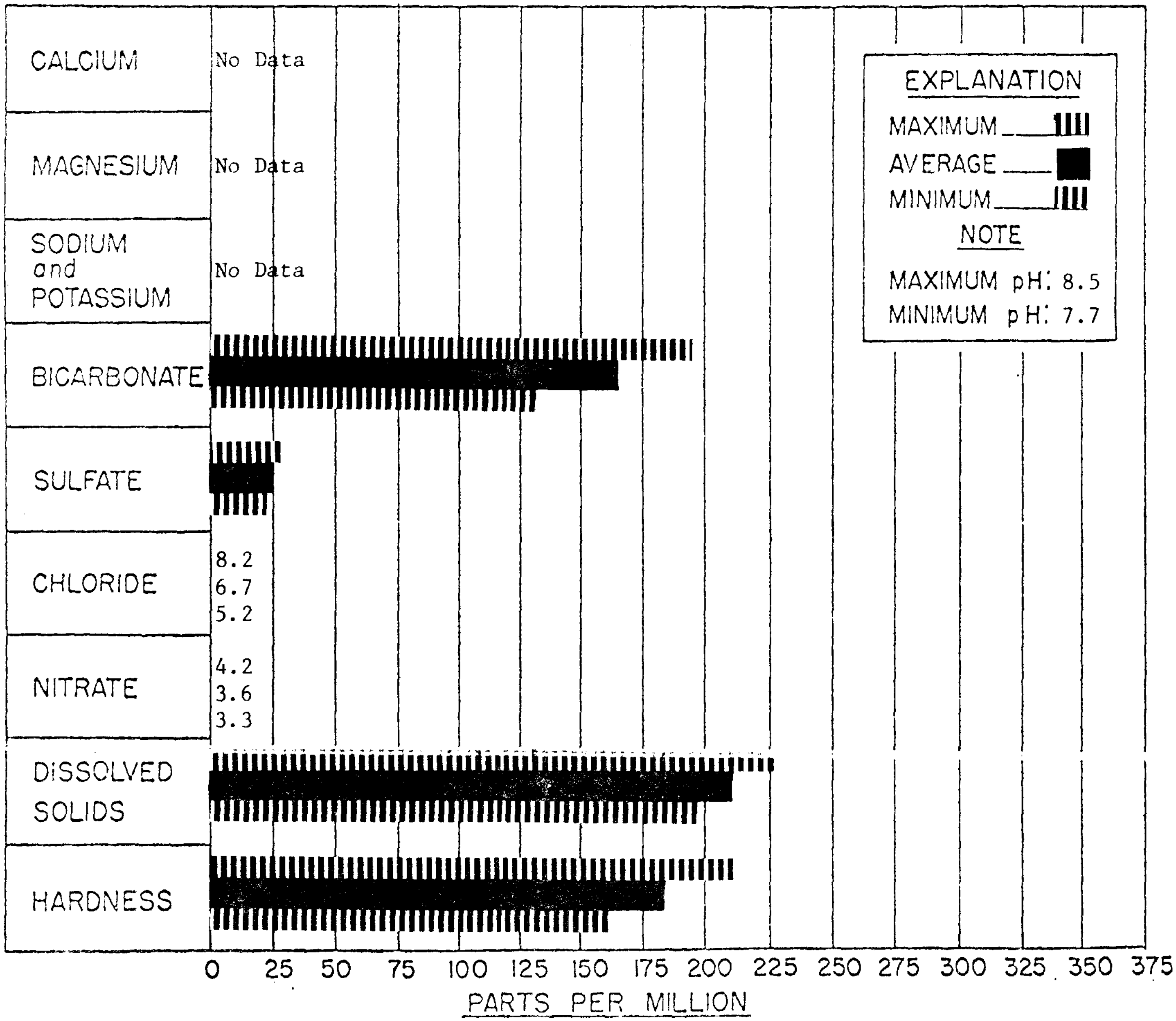
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE G-1

Salt River

Shepherdsville

11-65 to 11-74



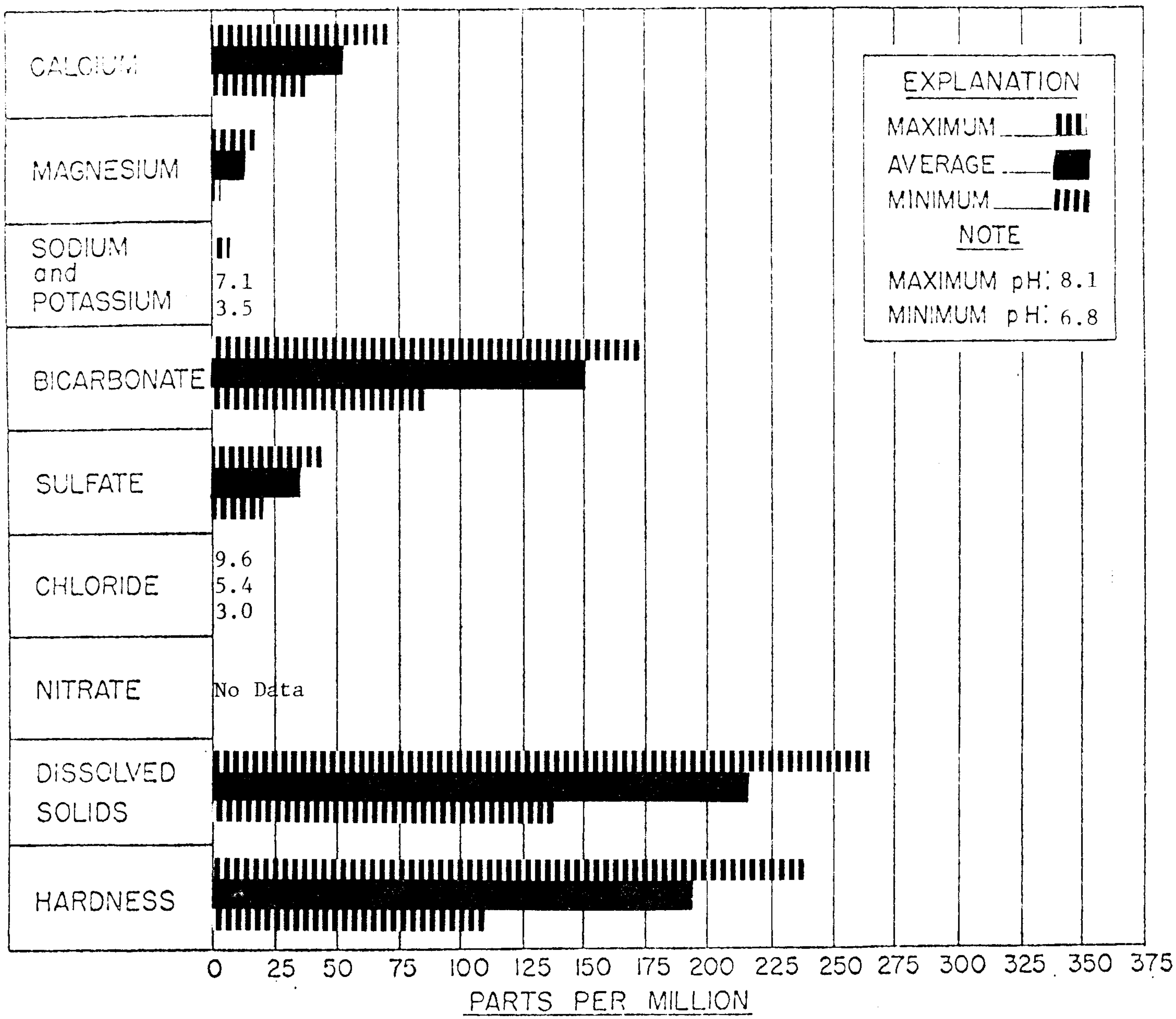
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE G-2

Rolling Fork

Boston

10-70 to 9-72



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE G-3

Rolling Fork

Lebanon Junction

10-74 to 12-75

average is low and, therefore, uniformity of water quality allows stable operation of water supply treatment plant and industry water usage is enhanced.

C. Trace Chemical Water Quality

Trace elements (under 5 mg/l) are separated from the general chemical background of this report because of their influence on human health. Generally, these materials are "heavy" metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State-Federal Water Quality Standards.

Trace chemicals in the surface water of the Salt River Basin in Kentucky were measured as being within Kentucky-Federal Water Quality Standards.

D. Waste Load Effects on Water Quality

Biochemically degradable wastes impose a load on the dissolved oxygen recourses of a stream. Such a waste load is considered to have an effect upon water quality when they cause the dissolved oxygen (D.O.) concentration to drop below the Kentucky Water Quality Standard of 5.0 mg/l. Based on a model developed for the Kentucky Continuing Planning Process for River Basin Management Planning, 596 miles of streams in the basin that receive waste discharges were evaluated.. On the basis of present treatment levels and once on 10 year 7 day low flows the model shows 160 stream miles (28 per cent of the miles modeled) are affected by discharges.

The types of facilities affecting the streams and the length affected are 61 miles (11 per cent) by municipal discharges; 8 miles (1.7 per cent) by industrial discharges, and 91 miles (15 per cent) by other discharges. A miscellaneous discharge is one that is privately owned, eg. subdivisions, schools, etc. (See Table G-5)

E. Non-Point Source Effects

The primary non-point source of pollution in the Salt River is from soil erosion. The sediment pollution comes from field and stream bank erosion. In 1973 about 100 sq. mi. associated with agricultural crop land had high erosion rates and there are approximately 50 miles of stream banks that are a critical sediment source.

F. Water Uses in the Basin

Water uses in the basin are public and industrial, recreation, fish and wildlife, and agricultural. The total public and industrial usage in the Salt River Basin is 10 million gallons per day (m.g.d.) from surface water at 9.6 m.g.d. and groundwater at 0.4 m.g.d. The industrial usage is 5.5 m.g.d., (groundwater 0.1 m.g.d., surface water 5.4 m.g.d.) and the public usage is 4.5 m.g.d., (groundwater 0.4 m.g.d. and surface water 4.1 m.g.d.). Water withdrawal during periods of low flow is not a problem since during periods of low flow the water is withdrawn from reservoirs.

There are no large commercial water recreation sites in this basin.

It is generally understood that the Salt River Basin is good in sport fishing.

The Kentucky Department of Fish and Wildlife Resources is studying the sport fishing in this basin and a report will be published in the next two years.

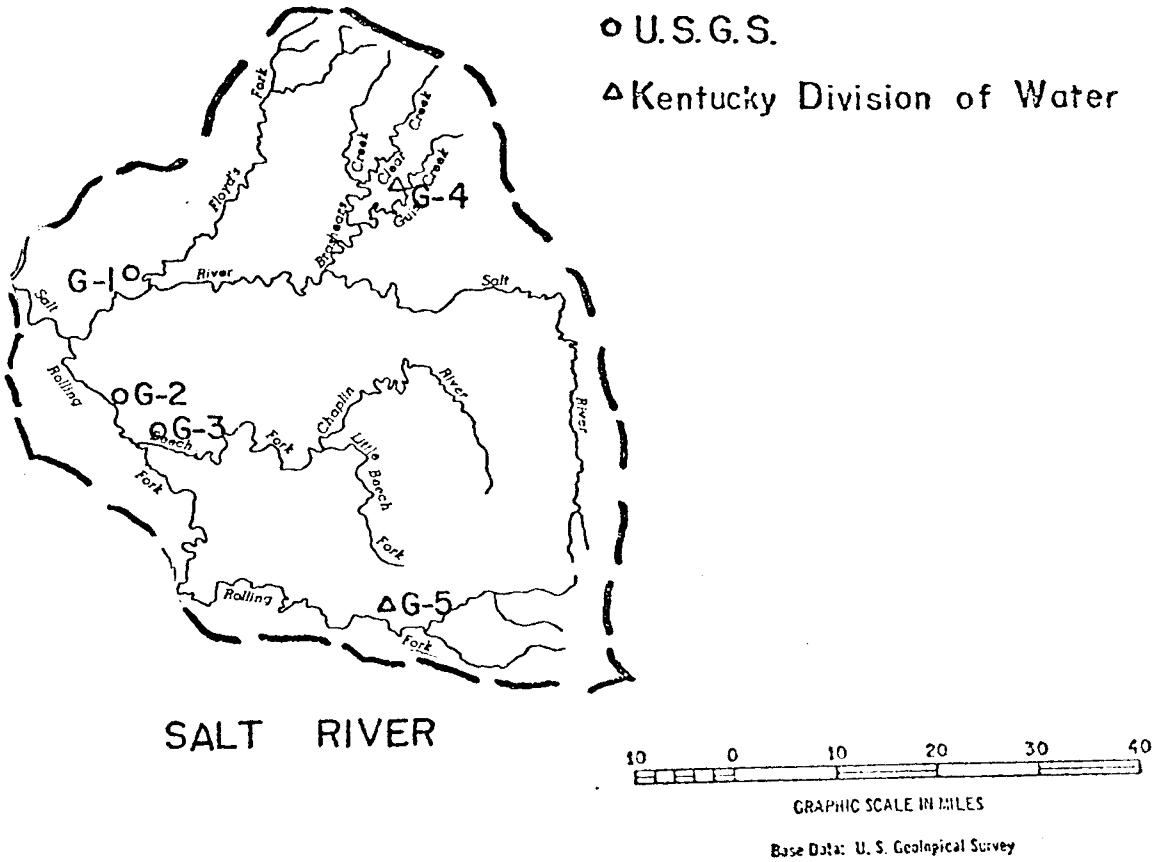
G. Water Quality Changes

Sedimentation data that was collected in the period of 1948 to 1954 indicated that the Salt River Basin had the largest sediment load of any basin in Kentucky. The effects of agricultural runoff and logging operations in relation to the topography created a difficult control problem from these sources of sediment load. Continued effort by the U.S.D.A. SCS by encouraging proper soil utilization should assist in controlling the sediment load problem.

The problem associated with municipal waste discharge into Pond Creek and Floyds Fork will be corrected in a comparatively short time by intercepting the waste and conveying this waste to a treatment facility to be located on the Ohio River. Therefore, the expected changes in water quality are for improvement in both sediment load and from maintenance of D.O. levels at or above the level of the State-Federal Water Quality Standards.

III. Summary

The general chemical and trace water quality in Kentucky's Salt River Basin has been shown to be of high quality. There are problems, however, related to other aspects of water quality in the basin that require attention and action to be corrected. Severe soil erosion from farming practices presents a major problem with excessive sediment in the water. Treated wastes discharged from municipal, independent and industrial sources effect the water quality of the basin's streams. Upgrading the treatment facility and improvement in operation and maintenance of waste treatment facilities is needed. A program of operator licensing and education to improve operation and maintenance is a significant part of the Division of Water Quality operations.



SALT RIVER

STATION KEY

G-1 SALT RIVER AT SHEPHERDSVILLE
G-2 ROLLING FORK AT LEBANON JUNCTION
G-3 ROLLING FORK AT BOSTON
G-4 GUIST CREEK AT SHELBYVILLE
G-5 ROLLING FORK AT LEBANON

TABLE G-2

Population in the Salt River Basin

County	City		Urban Population in Basin	Total Population in Basin	Area (sq. mi.)
Casey				4,150	94
Taylor				100	28
Larue				2,600	89
Hardin				49,000	140
	Fort Knox		37,608		
	Radcliff		7,881		
		Total	45,489		
Bullitt				26,090	300
	Mt. Washington		2,020		
Jefferson				323,000	220
	Louisville		79,919		
	Seneca Gardens		822		
	Strathmore		1,004		
	Jeffersontown		9,701		
	Fern Creek		6,000		
	Beuchel		9,000		
	Audubon Park		1,862		
	Newburg		4,000		
	Okolona		17,643		
	Prairie Village		3,000		
	Fairdale		2,500		
	Glengary		1,500		
	Valley		3,500		
	Medora		300		
		Total	166,882		
Oldham				5,750	64
	Crestwood		900		
	Pewee Valley		950		
			1,850		
Henry				1,087	14
	Pleasureville		747		
Shelby				15,900	314
	Shelbyville		4,182		
	Simpsonville		628		
	Veachland		700		
		Total	5,510		
Anderson				7,500	140
	Lawrenceburg		3,579		
	Stringtown		300		
			3,879		
Mercer				11,800	150
	Harrodsburg		6,741		
	Salvisa		350		
			7,091		

County	City		Urban Population in Basin	Total Population in Basin	Area (sq. mi.)
Boyle				4,600	100
	Mitchellsburg		500		
	Perryville		730		
		Total	1,230		
Marion					
	Bradfordsville		338	16,700	343
Nelson				23,480	437
	New Haven		977		
	Bardstown		5,816		
		Total	6,793		
Washington				10,730	307
	Loretto		985		
	Springfield		2,961		
			3,946		
Spencer				5,492	192
	Taylorsville		897		
		TOTAL	245,925	507,232	2,932

Source: 1970 U. S. Census as reported in the Rand McNally "Standard Reference Map and Guide of Kentucky"

TABLE G-3

Water Quality Data for Salt River Basin

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
STORET #00400	pH Specific Units, Ky. Std. 6 LT pH LT 9						
Salt R., Shepherdsville	75/02/14	75/02/14	7.2			1	
USGS #03298500	70/04/03	72/07/26	7.7	8.4	7.0	9	.444
	65/11/09	74/11/-	7.8	8.5	6.9	39	.5
Rolling Fk., Nr Leb Jct.	76/01/06	76/10/28	6.9	7.5	6.1	11	.425
USGS #03301630	74/01/08	76/10/28	7.2	8.1	6.1	26	.406
Rolling Fk., Nr Boston	70/10/05	72/09/01	8.2	8.5	7.7	3	.416
USGS #03301500							
STORET #00095	Conductivity Micro Mhos, Ky. Std 800 micro mhos						
Salt R., Shepherdsville	75/02/14	75/06/25	410	420	400	2	14.1
	70/04/03	74/06/11	403	537	176	18	81.5
	65/11/09	74/06/-	400	540	170	49	80
Rolling Fk. Nr Leb. Jct.	76/01/06	76/11/30	330.4	430.0	140.0	12	87.164
	74/10/08	76/11/30	347.6	455.0	140.0	27	73.829
Rolling Fk. Nr Boston	70/10/05	72/09/01	363	421	315	3	53.6
STORET # 70300	Residue mg/l Ky. Std. 500 mg/l						
Salt R., Shepherdsville	70/04/03	72/07/26	249	332	114	9	60.2
	65/11/09	72/07/26	248	336	114	37	49.6
	53/12/08	72/07/26	226	336	95	72	48.7
Rolling Fk. Nr Leb. Jct.	76/01/06	76/10/28	194.0	240.0	102.0	10	44.325
	74/10/08	76/10/28	208.7	266.0	102.0	25	40.073
Rolling Fk. Nr Boston	70/10/05	72/09/01	210	226	198	3	14.4
STORET #00410	Alkalinity mg/l, No standard						
Salt R., Shepherdsville	70/04/03	72/07/26	168	241	62	9	47.7
	66/10/19	72/07/26	167	241	62	17	38.3
Rolling Fk. Nr Leb. Jct.	76/01/06	76/10/28	132.9	174.0	62.0	10	37.617
	74/10/08	76/10/28	143.8	193.0	62.0	25	33.771
Rolling Fk. Nr Boston	70/10/05	72/09/01	162	192	130	3	31.0

Table G-3
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
STORET #00900	Hardness mg/l, 0-60 Soft, 61-120 Mod.Hard, 121-181 + Very Hard						
Salt R., Shepherdsville	70/04/03	72/07/26	203	280	80	9	53.3
	65/11/09	72/07/26	206	280	80	37	44.4
Rolling Fk. Nr Leb. Jct.	76/01/06	76/10/28	162.8	220.0	78.0	10	47.076
	74/10/08	76/10/28	176.3	240.0	78.0	25	39.879
Rolling Fk. Nr Leb.Jct.	70/10/05	72/09/01	183	210	160	3	25.2
STORET #00950	Fluoride mg/l, Ky. Std. 1.0 mg/l						
Salt R. Shepherdsville	70/10/05	72/07/26	0.22	0.30	0.20	4	.0500
	65/11/09	72/07/26	0.21	0.30	0.10	8	.0835
Rolling Fk. Nr Leb. Jct.	76/01/06	76/10/28	.264	.500	.100	11	.112
	74/10/08	76/10/28	.02	.500	.000	26	.105
Rolling Fk. Nr Boston	70/10/05	72/09/01	0.20	0.20		3	.0000
STORET #00915	Calcium mg/l, No Standard						
Salt R. Shepherdsville	70/04/03	72/07/26	59	90	26	3	32.0
	65/11/09	72/07/26	66	90	26	7	20.0
Rolling Fk. Nr Leb.Jct.	76/01/66	76/10/28	47.4	61.0	24.0	10	12.140
	74.10/08	76/10/28	51.5	71.0	24.0	25	10.856
STORET #00925	Magnesium mg/l, No standard						
Salt R., Shepherdsville	70/04/03	72/07/26	9.2	13.0	3.7	3	4.90
	65/11/09	72/07/26	12.5	18.0	3.7	7	4.45
Rolling Fk., Nr Leb. Jct.	76/01/06	76/10/28	11.1	17.0	4.3	10	4.021
	74/10/08	76/10/28	11.6	17.0	4.3	25	3.143
STORET #01049	Lead ug/l (micro-grams per liter), Ky. Std. 50 ug/l						
Salt R., Shepherdsville	75/02/14	75/06/25	2.3	3.0	1.0	3	1.15
	74/03/26	74/09/05	3.7	9.0	0.0	6	3.50
Rolling Fk. Nr Leb. Jct.	76/01/06	76/07/07	3.3	6.0	0.0	3	3.055
	74/10/08	76/07.07	4.1	10.0	.000	7	3.579

Table G-3
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
STORET #01000	Arsenic ug/l, Ky. Std. 50 ug/l						
Salt R., Shepherdsville	75/02/14	75/06/25	0.0	0.0	0.0	3	0.0
	74/03/26	74/09/05	2.5	4.0	1.0	6	1.38
Rolling Fk. Nr Leb Jct.	76/01/06	76/07/07	.3	1.0	0.0	3	.580
	74/10/08	76/07/07	.5	1.0	.000	8	.535
STORET #01025	Cadmium ug/l, Ky. Std. 100 ug/l						
Salt R., Shepherdsville	75/02/14	75/06/25	0.0	0.0	0.0	3	0.0
	74/03/26	74/09/05	0.3	1.0	0.0	6	0.52
Rolling Fk. Nr Leb Jct.	76/01/06	76/07/07	.7	1.0	0.0	3	.580
	74/10/08	76/07/07	1.9	7.0	.000	8	2.416
STORET #01030	Chromium ug/l, Ky. Std. 50 ug/l						
Salt R., Shephardsville	75/02/14	75/06/25	1.0	3.0	0.0	3	1.73
	74/03/26	74/09/05	0.8	3.0	0.0	6	1.17
Rolling Fk. Nr Leb Jct.	76/01/06	76/07/07	0.0	0.0	0.0	3	0.0
	74/10/08	76/07/07	.3	2.0	.000	8	.707
STORET #00080	Color Platinum Cobalt Units, Prop. EPA Std. 75 Units.						
Salt R., Shepherdsville	70/04/03	72/07/26	52	140	5	3	76.5
	65/11/09	72/07/26	26	140	1	7	50.3
STORET #00930	Sodium mg/l, No Standard						
Salt R., Shepherdsville	70/04/03	72/07/26	6.8	12.0	2.0	3	5.01
	65/11/09	72/07/26	6.6	12.0	2.0	7	2.95
Rolling Fk., Nr Leb. Jct.	76/01/06	76/10/28	4.0	6.1	1.4	10	1.473
	74/10/08	76/10/28	4.3	7.5	1.4	25	1.437
STORET #00935	Potassium mg/l, No Standard						
Salt R., Shepherdsville	70/04/03	72/07/26	3.1	4.0	2.3	3	0.85
	65/11/09	72/07/26	2.8	4.0	1.5	7	0.89
Rolling Fk., Nr Leb. Jct.	76/01/06	76/10/28	2.8	4.1	1.5	10	.972
	74/10/08	76/10/28	2.7	4.1	1.2	25	.912

Table G-3
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
STORET #00940	Chloride mg/l, proposed EPA Std. 250 mg/l						
Salt R., Shepherdsville	70/04/03	72/07/26	9.1	15.0	3.0	9	3.25
	65/11/09	72/07/26	8.8	19.0	3.0	37	2.90
Rolling Fk. Nr Leb. Jct.	76/01/06	76/10/28	5.0	6.8	2.3	10	1.483
	74/10/08	76/10/28	5.2	9.6	2.3	25	1.791
Rolling Fk. N. Boston	70/10/05	72/09/01	6.7	8.2	5.2	3	1.50
STORET #00945	Sulfate mg/l, proposed EPA Std. 250 mg/l						
Salt R., Shepherdsville	70/04/03	72/07/26	35	42	16	9	8.43
	65/11/09	72/07/26	35	48	16	37	7.76
Rolling Fk. Nr Leb. Jct.	76/01/06	76/10/28	28.5	43.0	14.0	10	9.229
	74/10/08	76/10/28	29.6	43.0	14.0	25	7.082
Rolling Fk. nr. Boston	70/10/75	72/09/01	25	27	22	3	2.52
	(No Data listed for 1976)						
STORET #71851	Nitrate mg/l, prop EPA Std 10 mg/l						
Salt R, Shepherdsville	70/04/03	72/07/26	5.5	11.0	1.5	9	3.02
	65/11/09	72/07/26	5.1	12.0	1.1	37	2.88
Rolling Fk., Boston	70/10/05	72/09/01	3.6	4.2	3.3	3	0.52

Bacteriological Data

Total Coliform Colonies per 100 ml. STORET #31503 Ky. Std. 1000/100 ml
Fecal Coliform Colonies per 100 ml. STORET #31616

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS	S
Guist Cr. Shelbyville WPI							
T. Coliform	75/01/30	75/12/23	302	2900	10	12	
	74/04/15	75/12/23	688	6800	10	17	
Salt R, Shepherdsville							
T. Coliform	75/01/30	75/12/17	5278	28000	100	11	
F. Coliform	75/05/15	75/12/17	945	6233	0	8	
	T C - No Data						S
Rolling Fk. Lebanon Ky. WPI T. Coliform	76/01/06	76/11/30	2151.2	12000.0	8.0	11	3639.65
	T C - No Data						
F C	75/02/12	76/11/30	2237.2	12000.0	8.0	21	3039.26

Table G-4

Municipal Population and Construction Grants Status in the Salt River Basin in Kentucky

County	City	Population	Project Type	Comments
Anderson	Lawrenceburg	3,579	1	Active
	(Alton Water District)	160	2	Active
Bullitt	Shepherdsville	2,769	1	Active
	Mt. Washington	2,020	none	Sewers/STP
	Lebanon Junction	1,571	1	Active
Henry	Eminence	2,225	none	Sewers/STP
Jefferson	Jeffersontown	9,701	2 & 3	Active
	Okolona	17,643	2	Active
			3	Pending
Marion	Lebanon	5,528	1	Active
Mercer	Harrodsburg	6,741	1 & 2	Active
Nelson	Bardstown	5,816	1	Active
			2	Pending
	New Haven	977	none	Sewers/STP
	Bloomfield	1,072	none	Sewers/STP
Shelby	Shelbyville (San. Dist. No. 1)	4,182	1	Active
	Simpsonville	628	1	Active
Washington	Springfield	2,761	1	Active

NOTE: Project type is related to the grant process step applied for or active for each municipality. Step 1 is the preliminary studies (201 Facilities Plan) required before design of the facilities. Step 2 is the design phase of the project, and Step 3 is the construction of facilities for the collection and treatment of wastewaters.

The comments relate to the status of the grant. Active indicates the project is funded and underway. Pending indicates that application for a grant has been made and is pending approval. No sewers indicates that the municipality does not presently have a comprehensive sewer system. Sewers/STP indicates the municipality is now served by sewers and treatment facilities.

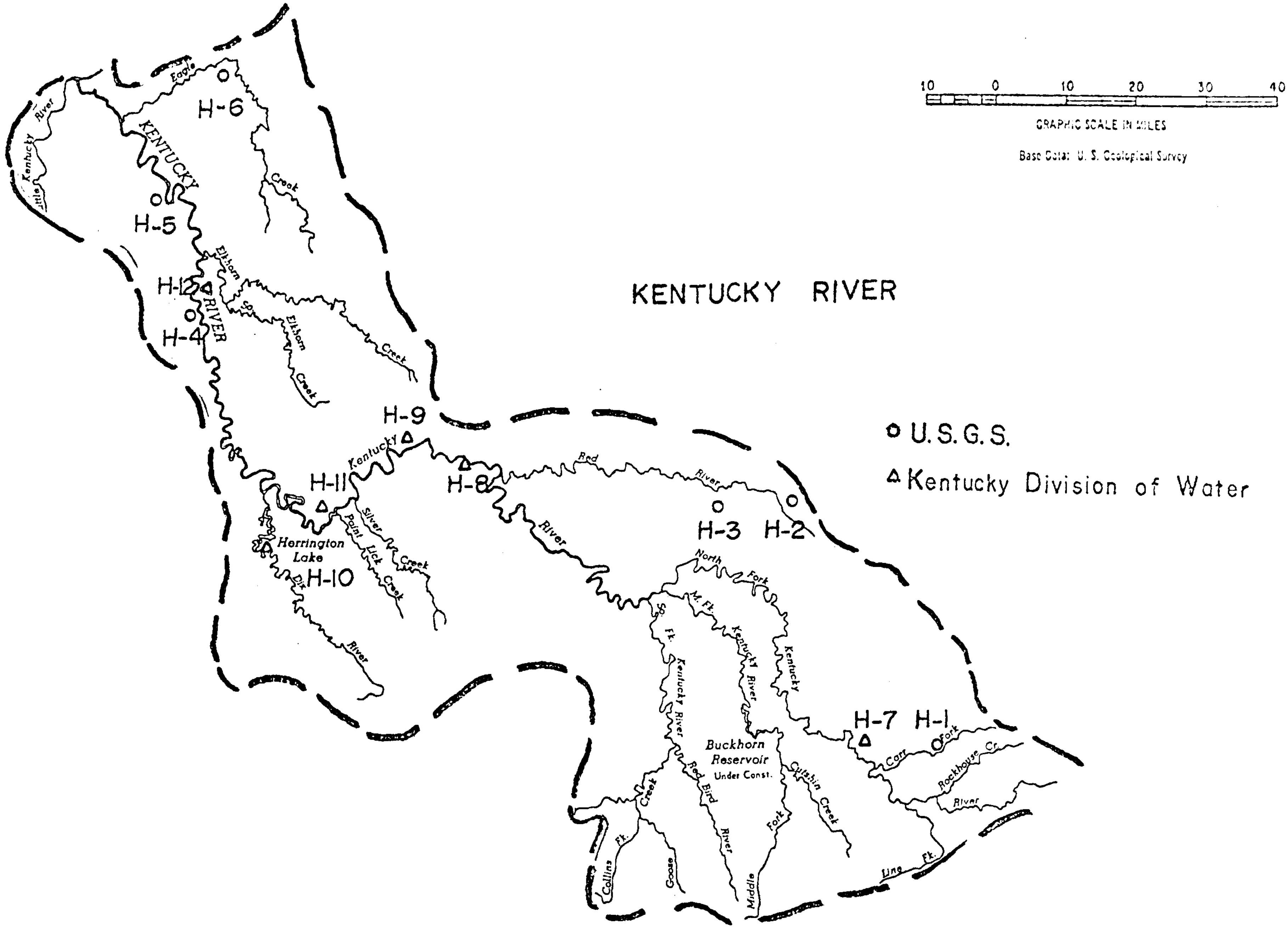
The source of this information was the 1970 U. S. Census and the FY 77 construction grants list for Kentucky.

TABLE G-5

Organic Loads Affecting Streams in the Salt River Basin

Length of streams to which treated organic loads are discharges		596 miles
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow		160 miles
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow		
	Municipal Discharges	66 miles
	Industrial Discharges	8 miles
	Other Discharges	91 miles

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e river basin planning effort. The values indicate the stream miles in which the dissolved oxygen is predicted to be less than 5 mg/l when the stream flow is less than the once in ten year seven day (Q_{10-7}) low flow.



KENTUCKY RIVER
10 0 10 20 30 40
GRAPHIC SCALE IN MILES
Base Data: U. S. Geological Survey
U.S.G.S.
Kentucky Division of Water
H-1
H-2
H-3
H-4
H-5
H-6
H-7
H-8
H-9
H-10
H-11
H-12
KENTUCKY
RIVER
Eagle
Creek
Little Kentucky River
Elkhorn
So. Elkhorn Creek
Creek
Kentucky
Red
River
River
Herrington Lake
Dix
River
Paint Lick Creek
Silver Creek
North Fork
M. Fk.
Kentucky River
Kentucky
So. Fk.
Kentucky River
Buckhorn Reservoir
Under Const.
Red Bird River
Middle Fork
Cutshin Creek
Carr Fork
Rockhouse Cr.
River
Line Fk.
Collins Fk.
Goose Creek

THE KENTUCKY RIVER BASIN

This report is basically divided into two main sections, the first section being a description of the basin and the second section dealing with the quality of the water in the basin.

The first section is entitled "Basin Description" and describes the geography, topography, geology, hydrology and population characteristics within the Kentucky River Basin.

The second section of the report is entitled "Basin Water Quality" and describes the quality of the water with respect to general chemical, trace chemical, waste load effects, non-point source effects, uses, and changes.

I. A Description of the Kentucky River Basin

A. Geography

In an effort to better describe the Kentucky River Basin it will be divided into two sections. The first section (hereinafter referred to as the "Headwater Section") begins at the headwaters and ends at the City of Irvine and includes the three major forks of the river and 37 miles of its main stem. The remainder of the basin (hereinafter referred to as the "Bluegrass Section") will further be divided into inner and outer sections. The main stem of the Kentucky River is 255.5 miles long from its mouth to the confluence of the North, Middle and South Forks.

The Kentucky River Basin lies wholly within the State of Kentucky and the river flows in a northwesterly direction. It begins in southeastern Kentucky, flows through the central part of the state and empties into the Ohio River at mile point 435.6 in North Central Kentucky.

The total area of the basin is 7,033 sq. mi. and contains eight sub-basins with areas of over two hundred sq. mi. (See Table H-1) The basin contains, either wholly or partially, 36 of the 120 counties in the State. (See Table H-2)

B. Topography

The Headwater Section is a mountainous area and is heavily mined for coal. Therefore, the water has a considerable sulfate content and is slightly acidic in the immediate coal mining areas. The average slope of the tributaries in this section ranges from 3 ft./mi. to 7.2 ft./mi. which are moderate slopes and it can therefore be said that the waste load assimilation capacity of the tributaries in this section is moderate. The average slope of the main stem of the river in this section is approximately 0.9 ft./mi. which is a low slope for reaeration.

The maximum elevations of the tributaries in this section range from 760 feet to 1,250 feet mean sea level (m.s.l.). It should be noted that water will hold about 2 per cent less dissolved oxygen for every 500 feet in elevation above sea level. Therefore, the dissolved oxygen capacity of these streams is retarded by approximately 4 per cent.

The Bluegrass Section lies in north-central Kentucky and is a structurally high but physiographically level area. The average slope of the tributaries in this section ranges from approximately 3 feet per mile to 32 feet per mile which are moderate to high and it can therefore be said that the waste load assimilation capacity of the tributaries in this section are moderate to high. The average slope of the main stem of the river in this section is approximately 0.7 ft./mi.

The maximum elevations of the tributaries in this section range from 710 feet to 950 feet m.s.l. and therefore the dissolved oxygen capacity of these streams is retarded by approximately 3 per cent. (For more detailed information regarding slopes and elevations see Table H-3)

C. Geology

For the purposes of this report the most significant geological feature in the Headwater Section is the coal resources. Due to the mining activities including the stripping, washing, and loading of coal, there is a great amount of exposed coal in this area. The runoff is rapid and carries a considerable amount of solids to the streams. There are also thin beds of limestone in this area which contribute to the hardness of the water. Because of greater relief and the resulting more rapid runoff of surface water and drainage of groundwater from exposed strata, groundwater is not available in adequate amounts for water supply. Groundwater supplies diminish in dry weather owing to the paucity of groundwater storage.

The Bluegrass Section can be divided into inner and outer sections with regards to geology, the inner bluegrass being underlain by thick, pure limestone and the outer bluegrass by outward dipping thin beds of limestone and shale. The limestone of the inner bluegrass, though thick and soluble, contains shaly zones which are important because they limit the circulation of water and the development of permeable zones. In the outer bluegrass the conditions are even less favorable because the limestone beds are thinner and there is more inner bedded shale. Limestone that underlies shale will rarely yield much water except near streams that have cut through the shale. The only wells in bedrock that produce more than 100 gallons per minute are in thick limestone in the inner bluegrass. Nearly all successful wells in bedrock are less than 100 feet deep. In the bluegrass region as a whole the groundwater is hard to very hard. About one-eighth of the existing wells are reported to yield water containing excessive sodium and chloride, and about one-fifth yield water containing noticeable amounts of hydrogen sulfide.

D. Hydrology

The Kentucky River has fourteen dams (See Table H-8) which restrict the flow and cause a decrease in reaeration rates, therefore causing the dissolved oxygen content to be reduced when an organic load is imposed on the stream. Furthermore, the slow moving water allows suspended solids to settle causing sludge deposits which impose a demand on dissolved oxygen and can hamper navigation unless removed.

There are two water withdrawals in the basin that are significant to water quality. The City of Lexington withdraws from the Kentucky River but discharges to tributaries which enter the river below Lock 4, and the City of Winchester withdraws from the Kentucky River but discharges to another basin. The City of Winchester withdraws approximately 1.5 MGD and the City of Lexington withdraws approximately 28 MGD. These two withdrawals are not put back in the river above Lock 4 near Frankfort and therefore reduce the once in seven day, ten year low flow at the Lock by the total 29,500,000 gallons per day or approximately by 20 per cent. This reduced low flow can affect the waste load allocation and subsequent treatment levels required for the cities of Richmond and Berea.

The City of Lawrenceburg also withdraws from the Kentucky River and discharges into another basin but this withdrawal has no significant impact on water quality.

The average normal flow of the Kentucky River at Locks 14, 10, and 4 are 3,369 cubic feet per second, 5,279 cubic feet per second, and 7,199 cubic feet per second respectively. The average yield of the basin is 1.3 cubic feet per second per square mile throughout the main stem of the river. Table H-4 expands on the flow records.

TABLE H-4

SURFACE WATER RECORDS FOR THE KENTUCKY RIVER BASIN

STATION	PERIOD OF RECORD	DRAINAGE AREA	AVERAGE FLOW	MAXIMUM FLOW	MINIMUM FLOW	7-day/10 yr. LOW FLOW
N. Fork of KY. River at Hazard	36 yrs.	466 sq.mi.	581 cfs, 1.2cfs*/sq.mi.	47,800 cfs, 103cfs/sq.mi.	Not determined	93 cfs
	wtr/yr 1976		447 cfs, 1.0 cfs/sq.mi.	13,400 cfs, 29cfs/sq.mi.	9 cfs, 0.0cfs/sq.mi.	
Lock 14 near Heidelberg **	44 yr.	2,657 sq.mi.	3,638 cfs, 1.4cfs/sq.mi.	120,000 cfs, 45cfs/sq.mi.	4.0 cfs, 0.0cfs/sq.mi.	120 cfs
	wtr/yr 1976		3,580 cfs, 1.3cfs/sq.mi.	41,100 cfs, 15cfs/sq.mi.	155 cfs, 0.1cfs/sq.mi.	
Lock 10 near Winchester**	69 yr.	3,955 sq.mi.	5,279 cfs, 1.3cfs/sq.mi.	92,400 cfs, 23cfs/sq.mi.	10 cfs, 0.0cfs/sq.mi.	160 cfs
	wtr/yr 1976		4,926 cfs, 1.2cfs/sq.mi.	38,200 cfs, 10cfs/sq.mi.	232 cfs, 0.1cfs/sq.mi.	
Lock 4 near Frankfort ***	51 yr.	5,412 sq.mi.	7,109 cfs, 1.3cfs/sq.mi.	115,000 cfs, 21cfs/sq.mi.	Not determined	270 cfs
	wtr/yr 1976		6,599 cfs, 1.2cfs/sq.mi.	47,700 cfs, 9cfs/sq.mi.	402 cfs, 0.1cfs/sq.mi.	

Table H-4
Continued

STATION	PERIOD OF RECORD	DRAINAGE AREA	AVERAGE FLOW	MAXIMUM FLOW	MINIMUM FLOW	7-day/10 yr. LOW FLOW
Elkhorn Creek near Frankfort	39 yr.	473 sq.mi.	612 cfs, 1.3cfs/sq.mi.	23,200 cfs, 49cfs/sq.mi.	0 cfs	28 cfs****
	wtr/yr 1976		566 cfs, 1.2cfs/sq.mi.	12,700 cfs, 27cfs/sq.mi.	32 cfs, 0.1cfs/sq.mi.	

* Cubic feet per second

** Flow regulated by Buckhorn Lake beginning December, 1960.

*** Flow regulated by Buckhorn Lake since December, 1960, By Herrington Lake since November, 1925, and by a Hydroelectric plant at Lock 7.

**** Low flow contribution from main Lexington Town Branch Plant, 18 MGD (28 cfs).

NOTE: Data is taken from "Surface Water Records in Kentucky" by the United States Geological Survey. The 7-day/10-yr. low flow was taken from the waste load allocation produced as a component of the 303e River Basin Continuing Planning Process.

There are fifteen lakes (See Table H-5) located in this basin with a total combined volume of 286,000 acre feet and a total combined surface area of 6,530 acres. The only lakes considered in the Kentucky basin report are those whose volume is greater than 1,000 acre feet or have a surface area greater than 100 acres. Two of these lakes, Buckhorn Lake and Carr Fork Lake, are Federal installations with a combined volume of 28,000 acre feet. The Buckhorn Lake (22,000 acre feet) is regulated to meet flood, recreation, fish and wildlife and low flow augmentation objectives. The low flow augmentation objective aides the stream below the lake during periods of low flow by means of dilution and reaeration. The Carr Fork Lake (6,000 acre feet) has not been in operation long enough to determine its effects upon the stream below it.

E. Population

The total population in the basin is 534,400 with the rural population being 291,200 or 55 per cent of the total population. There are forty-two incorporated cities in the basin representing the remaining 243,200 people. The major concentration of population is in the inner bluegrass region in the adjoining counties of Fayette, Madison, Franklin, Scott and Woodford. These five counties represent 283,900 people or 53 per cent of the total population in the basin. (See Table H-6)

. Basin Water Quality

A. Description of Sampling Stations

The water quality data presented in the next two sections of this eport was collected at six sampling station. Three of these station are located on the main stem of the river at Lock 2 near Lockport, at Lock 4 near Frankfort and at the Lexington water treatment plant near I-75 in southern Fayette County. The other three stations are located on major tributaries thusly: North Fork of the Kentucky River at Hazard having 466 square miles above it, the station on the Red River having 180 square miles above it, the station on the main stem at Lexington having 4,015 square miles above it, the station on Eagle Creek at Glencoe having 430 square miles above it, and the station on the main stem at Lock 4 having 5,412 square miles above it. The summary of the raw water quality data is in Table H-9.

The station on the North Fork at Hazard was purposely chosen to represent water quality data in a coal mining area. The other four stations are more indicative of the general water quality in the Kentucky River Basin.

B. General Chemical Water Quality

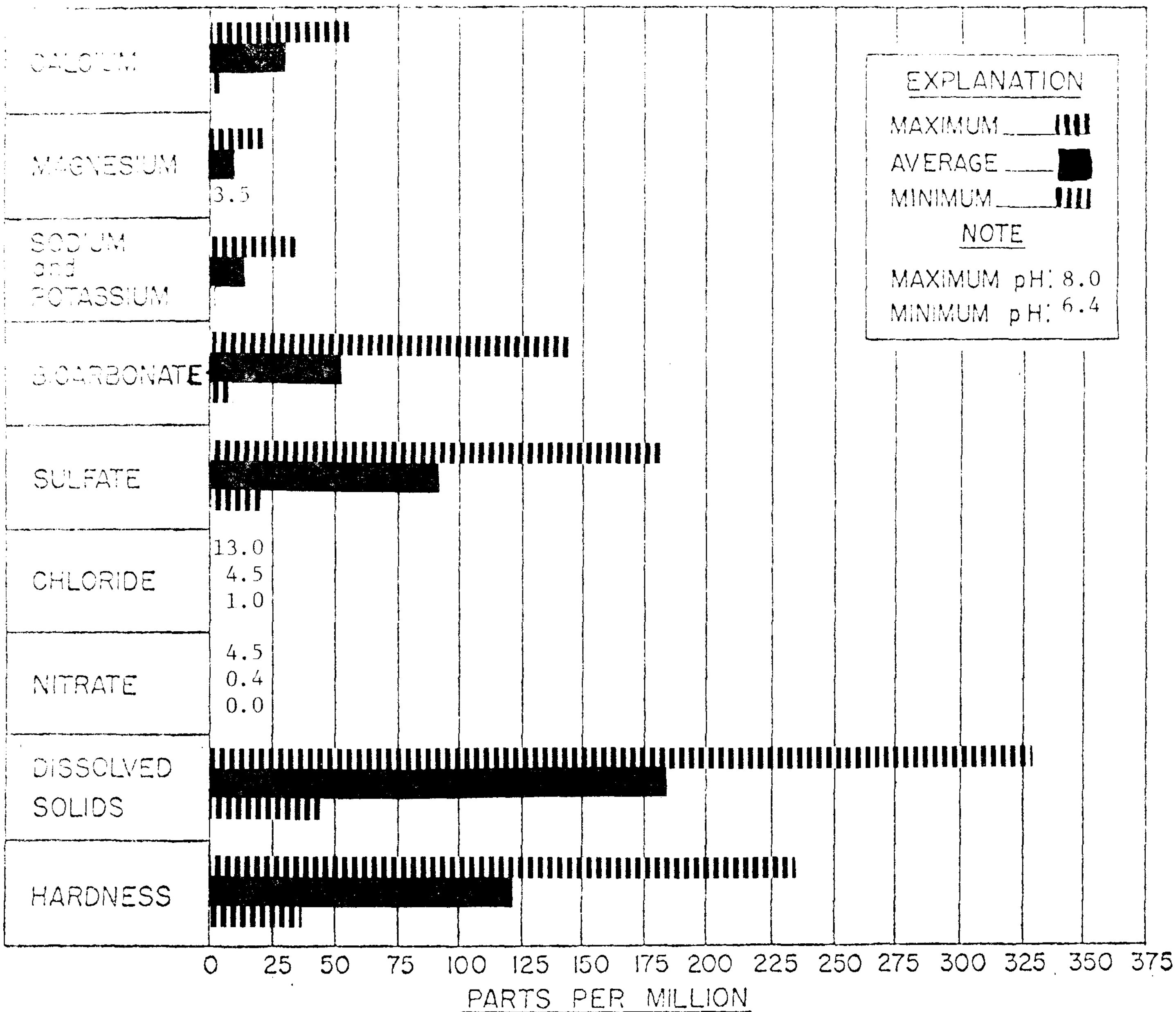
The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids, by examining the relationships of groups of chemicals, the type of water whether hard or soft, slaty, acid or high in sulfates reflects the mix of surface and groundwater. The chemical characteristics of a stream when viewed over a long period of time is primarily from surface water. The type of rock formation and soils which the surface water contacts causes this predominate chemical characteristic . The contribution of groundwater, which is generally higher in dissolved solids than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky is one of moderate hardness caused by calcium and magnesium salts. The influence of mining activities are clearly indicated when the sulfate content increases to a high level than the bicarbonate content, and the pH is on the acid side, below pH 5.5.

Oil field operations, when brine is encountered, are reflected by changes in soidum and chloride contents of the water. For Kentucky water, the influence is pronounced when either chloride or sodium exceeds 20 - 25 parts per million as an average value.

The overall water quality for the Kentucky River Basin is represented by the station at Lock 4 near Frankfort, Eagle Creek at Glencoe and Red River at Pine Ridge demonstrate the water quality for sensitive streams. This means that water quality parameters have a wide range with respect to the average value.

Reference is made to Figures H-10, H-11 and H-12 which represent data for Eagle Creek at Glencoe for the period of 1-75 to 11-75, 2-73 to 11-74, and 1-62 to 11-74, respectively. Water Quality at Eagle Creek at Glencoe indicates that the water is very hard meaning that the calcium carbonate hardness is greater than 180 mg/l. Water in this sub-basin tends to be periodically acidic. The data indicates that the bicarbonate alkalinity is high providing a good inorganic load buffering capacity in this particular stream. The overall water quality in this sub-basin is good.

Relative to the Eagle Creek Basin, the water quality in the Red River at Pine Ridge has a higher quality as demonstrated by Figures H-4 and H-5. This is indicated by water characterized as soft (calcium carbonate hardness



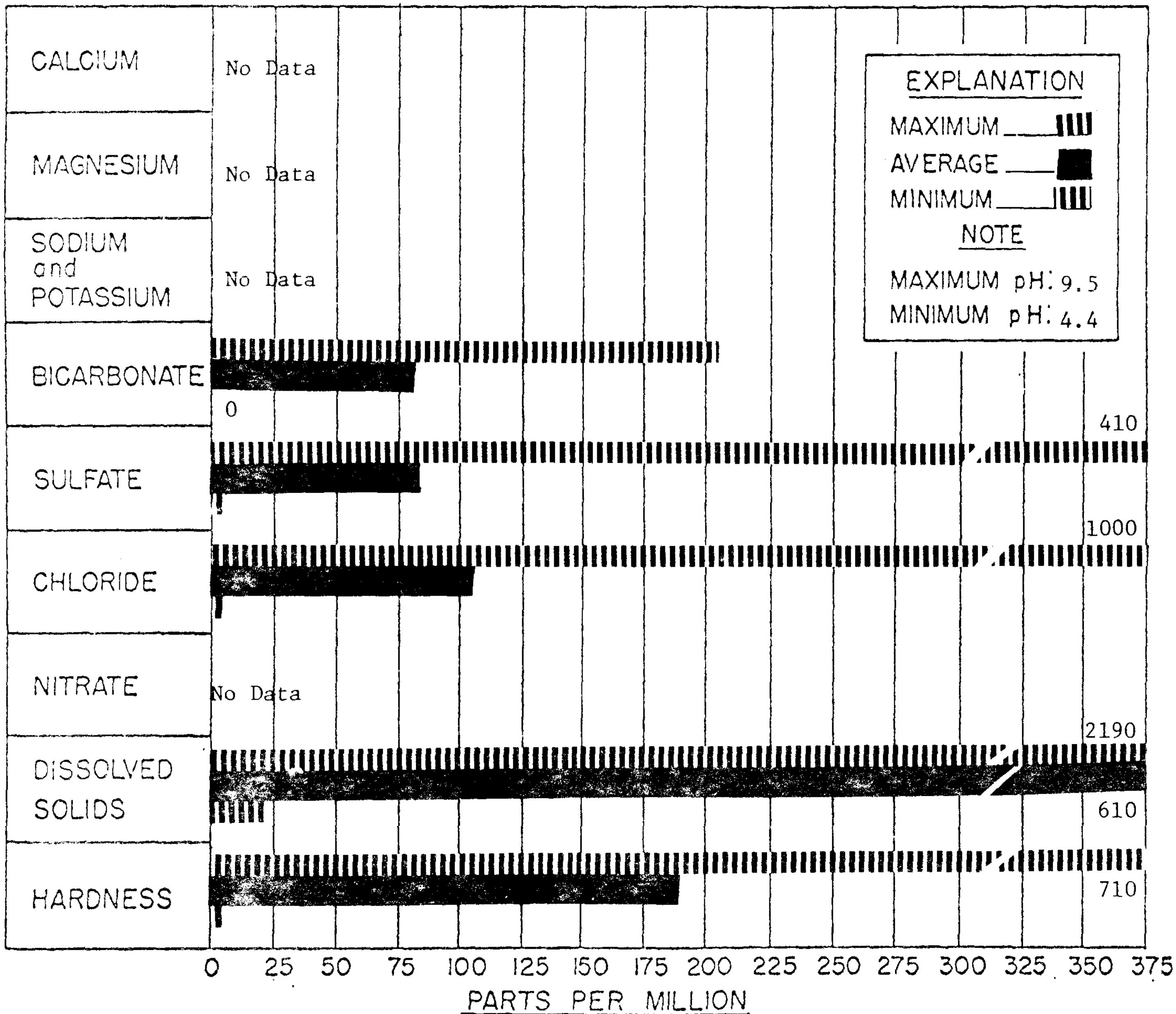
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE H-1

Carr Fork

Sassafras

7-70 to 12-74



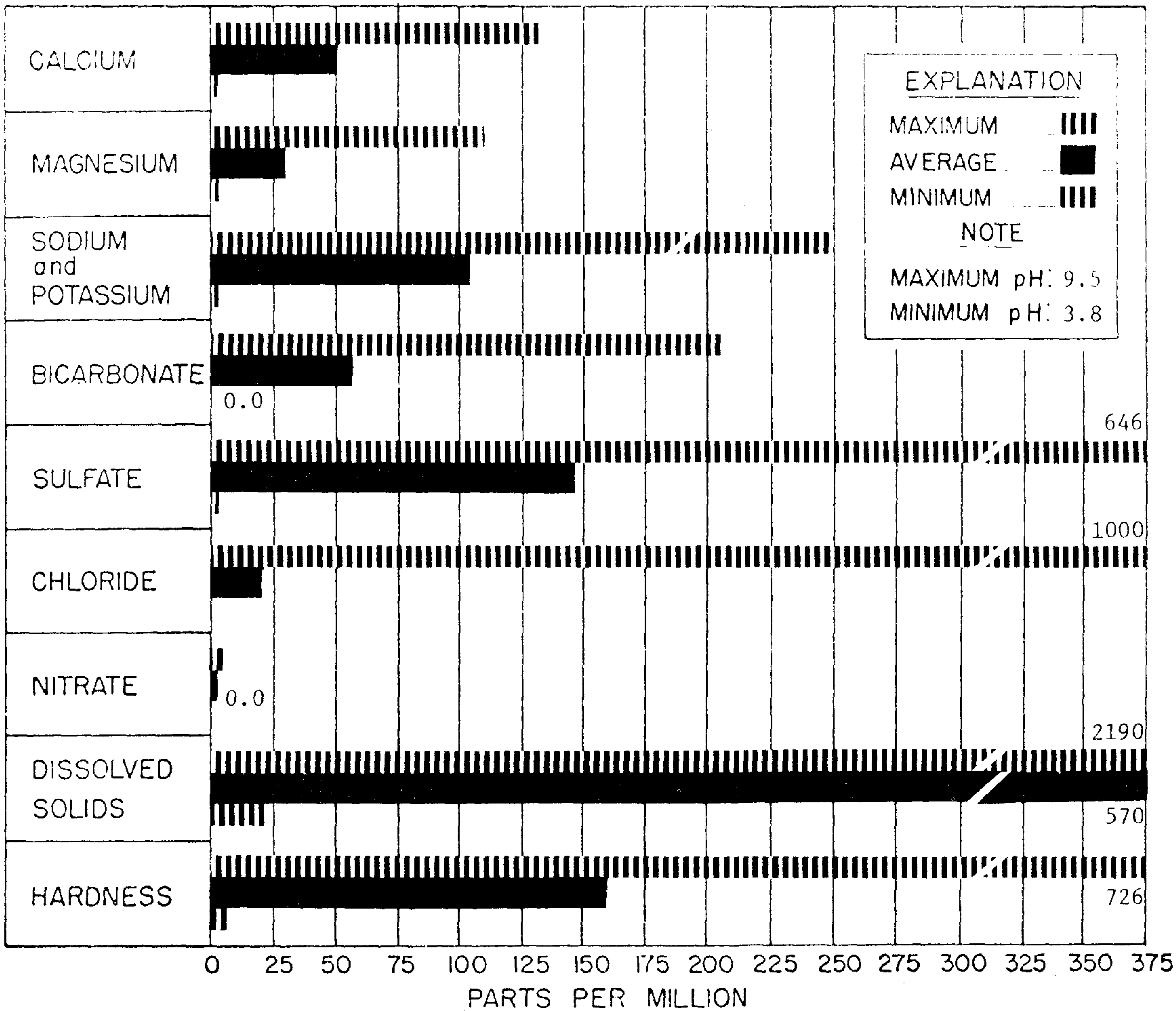
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE H-2

North Fork Kentucky River

Hazard

1-73 to 6-74



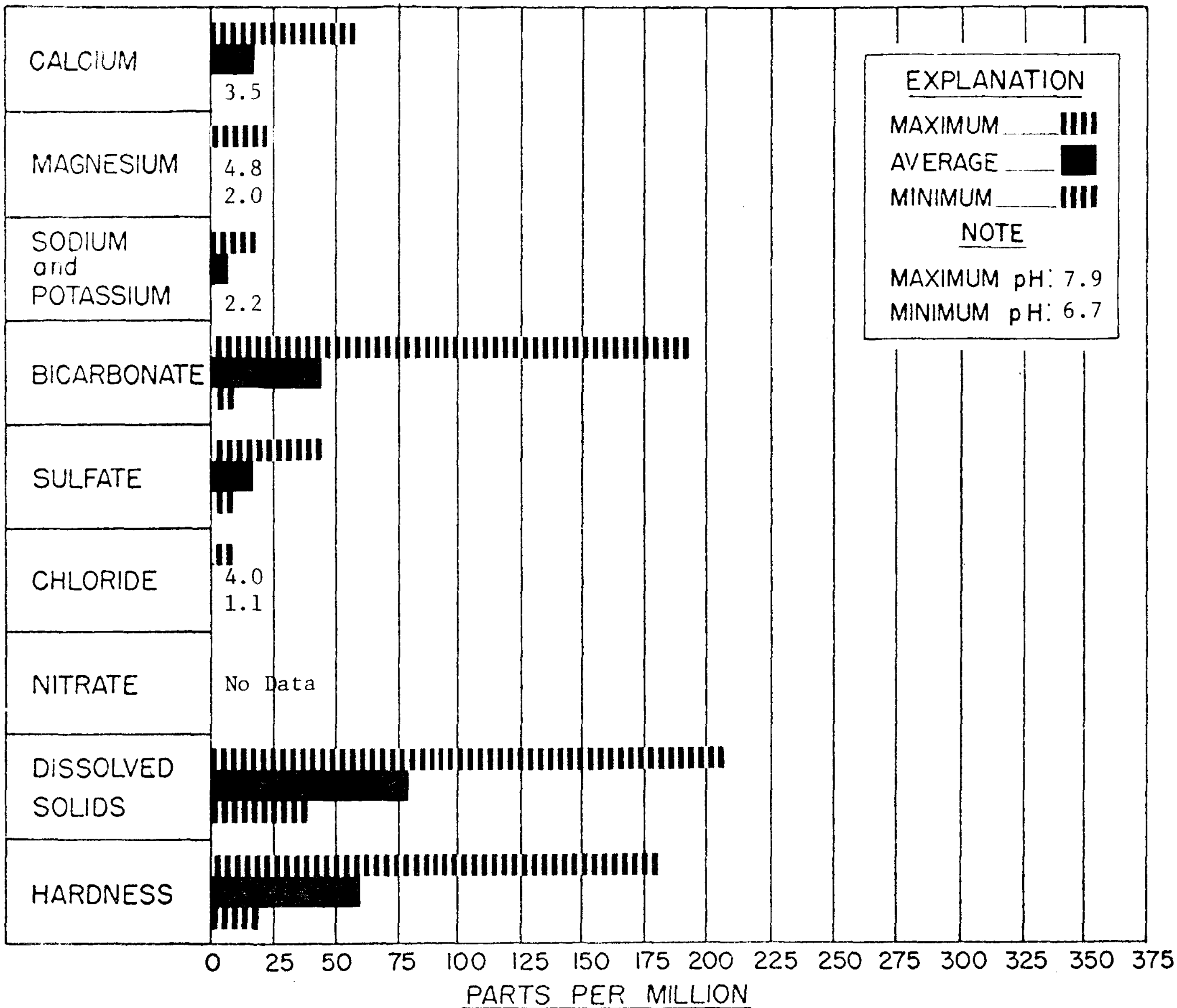
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE H-3

North Fork Kentu River

Hazard

10-62 to 6-74



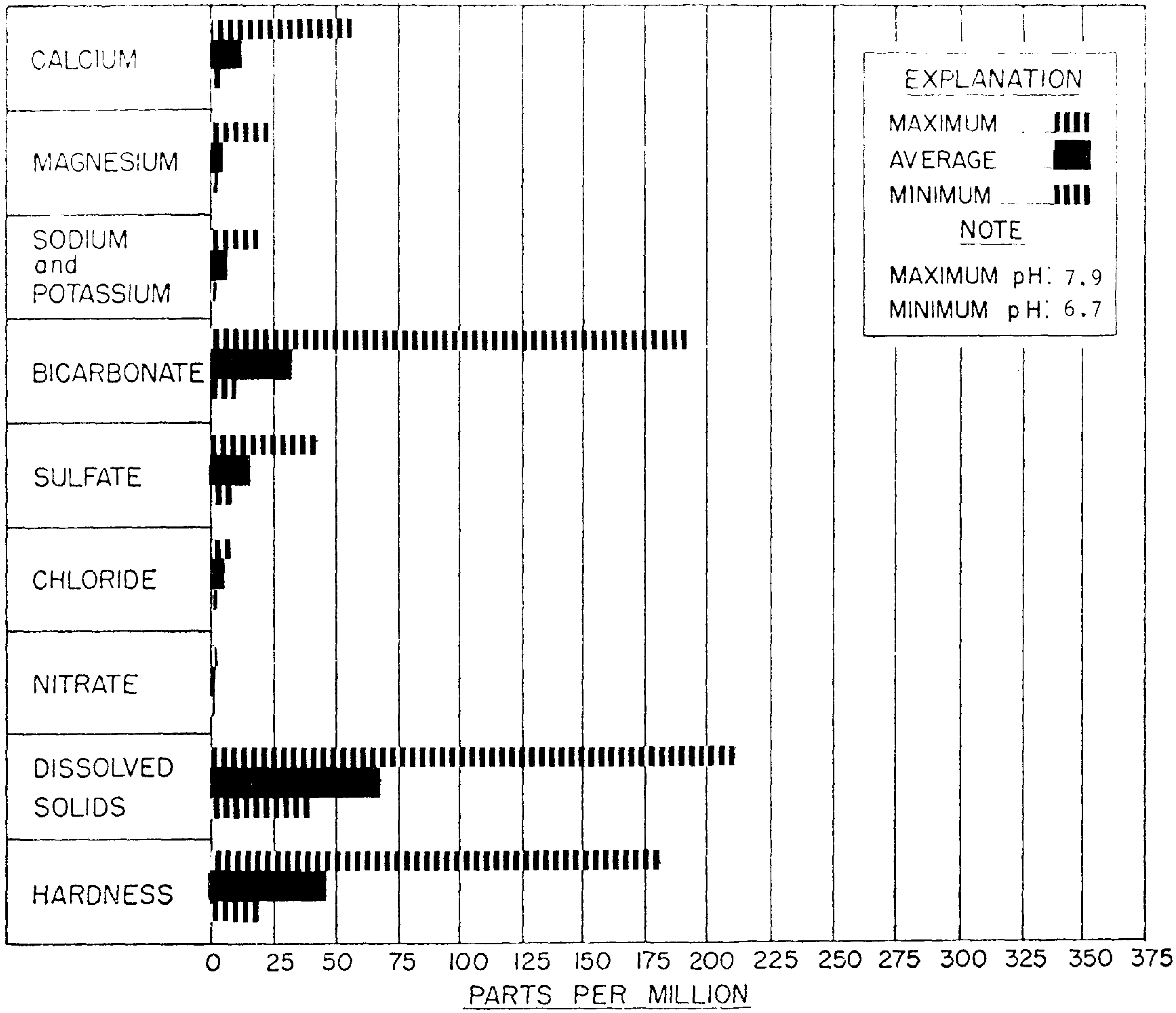
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE H-4

Red River

Pine Ridge

1-73 to 11-74



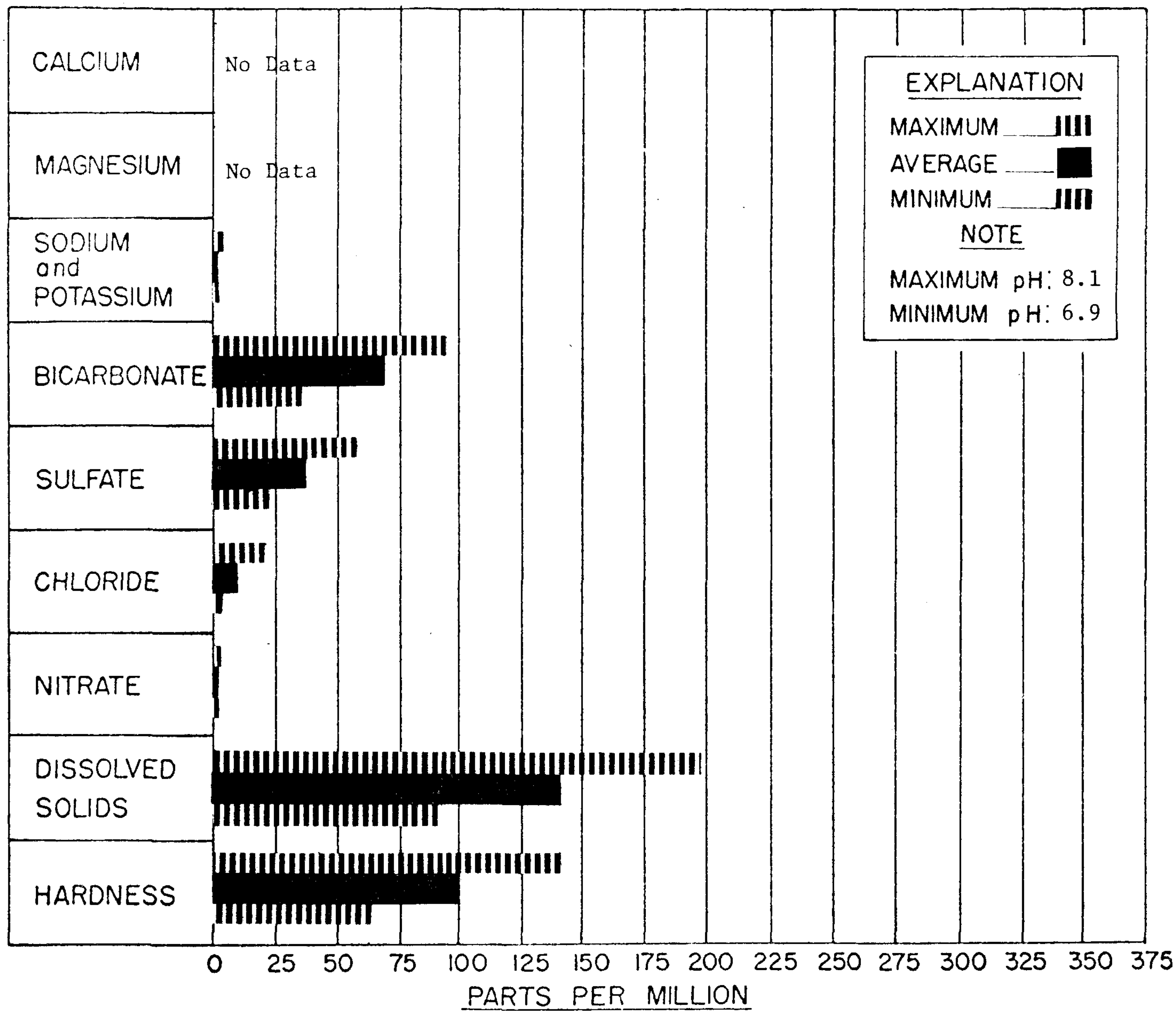
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE H-5

Red River

Pine Ridge

4-69 to 11-74



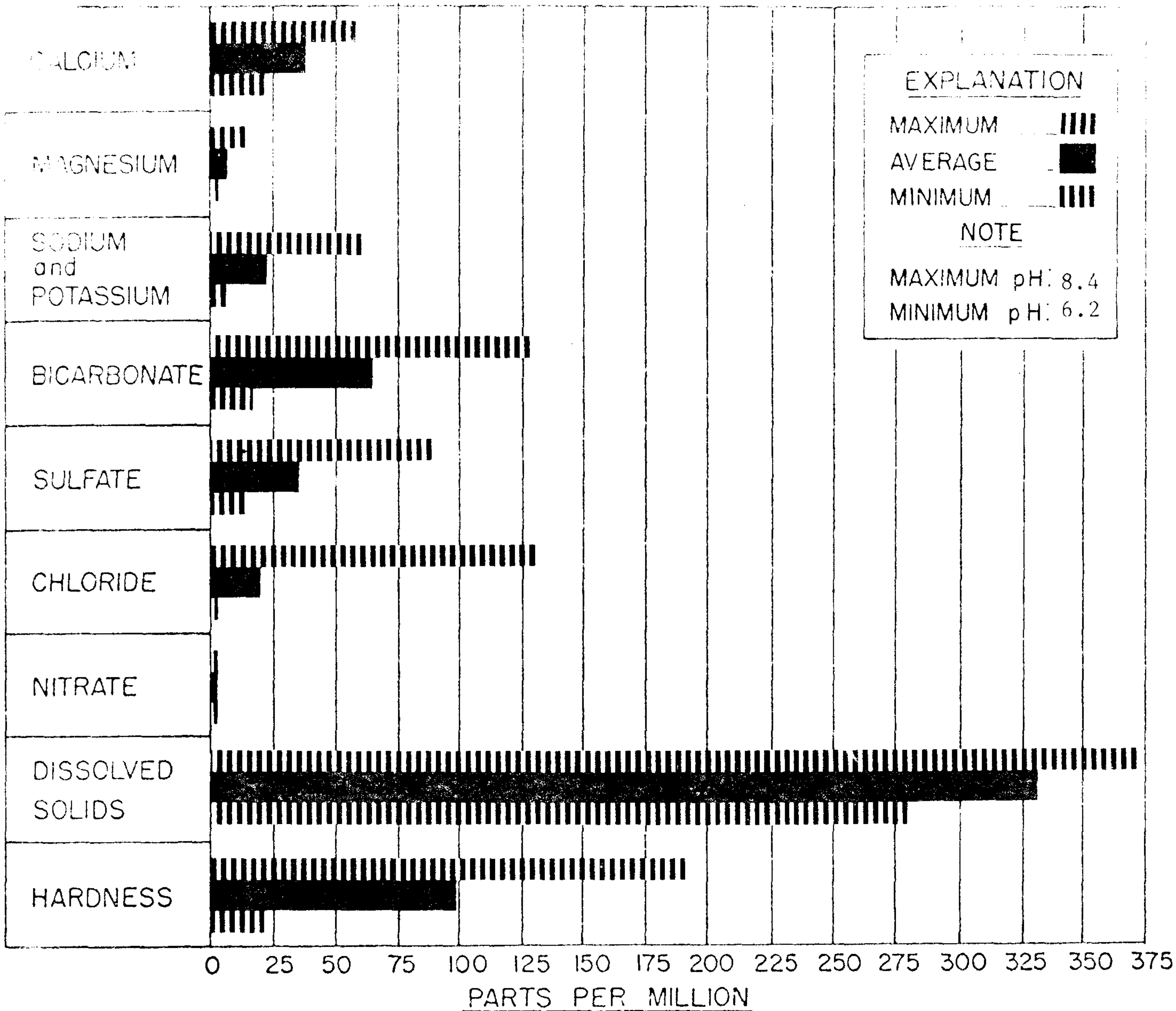
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE H-6

Kentucky River

Lock 4 at Frankfort

1-73 to 11-74



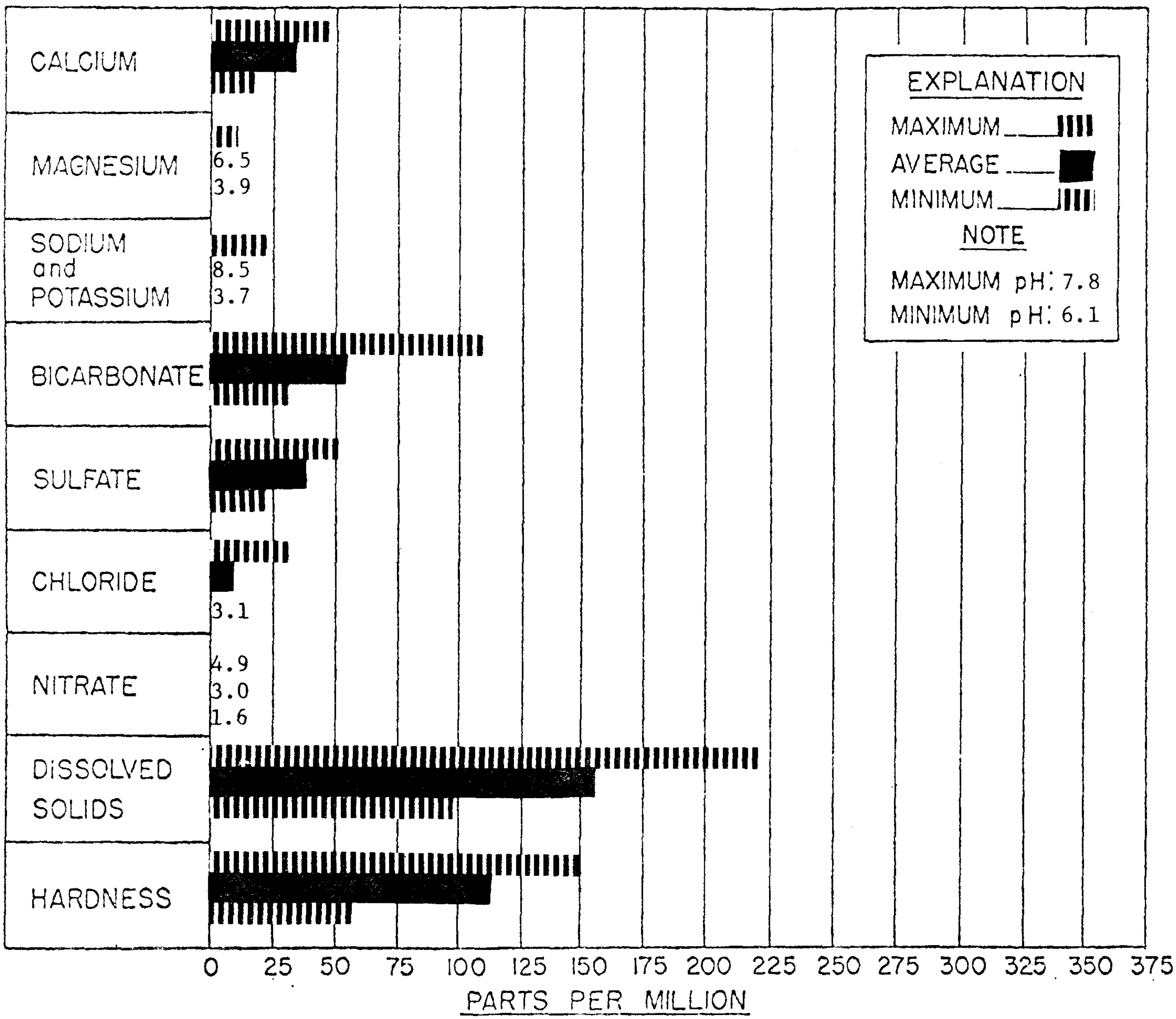
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE H-7

Kentucky River

Lock 4 at Frankfort

10-59 to 9-73



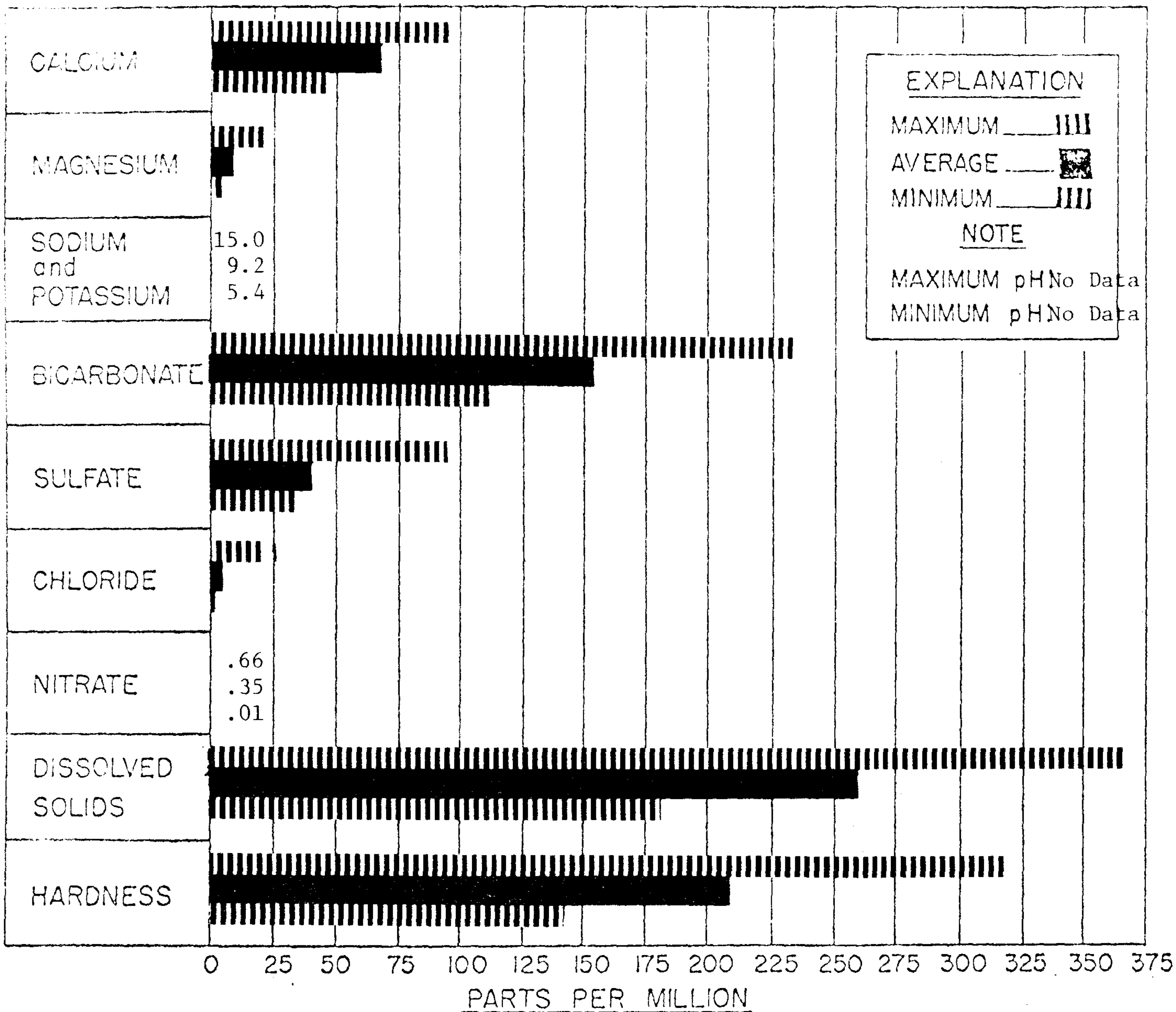
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE H-9

Kentucky River

Lock 2

2-73 to 1-76



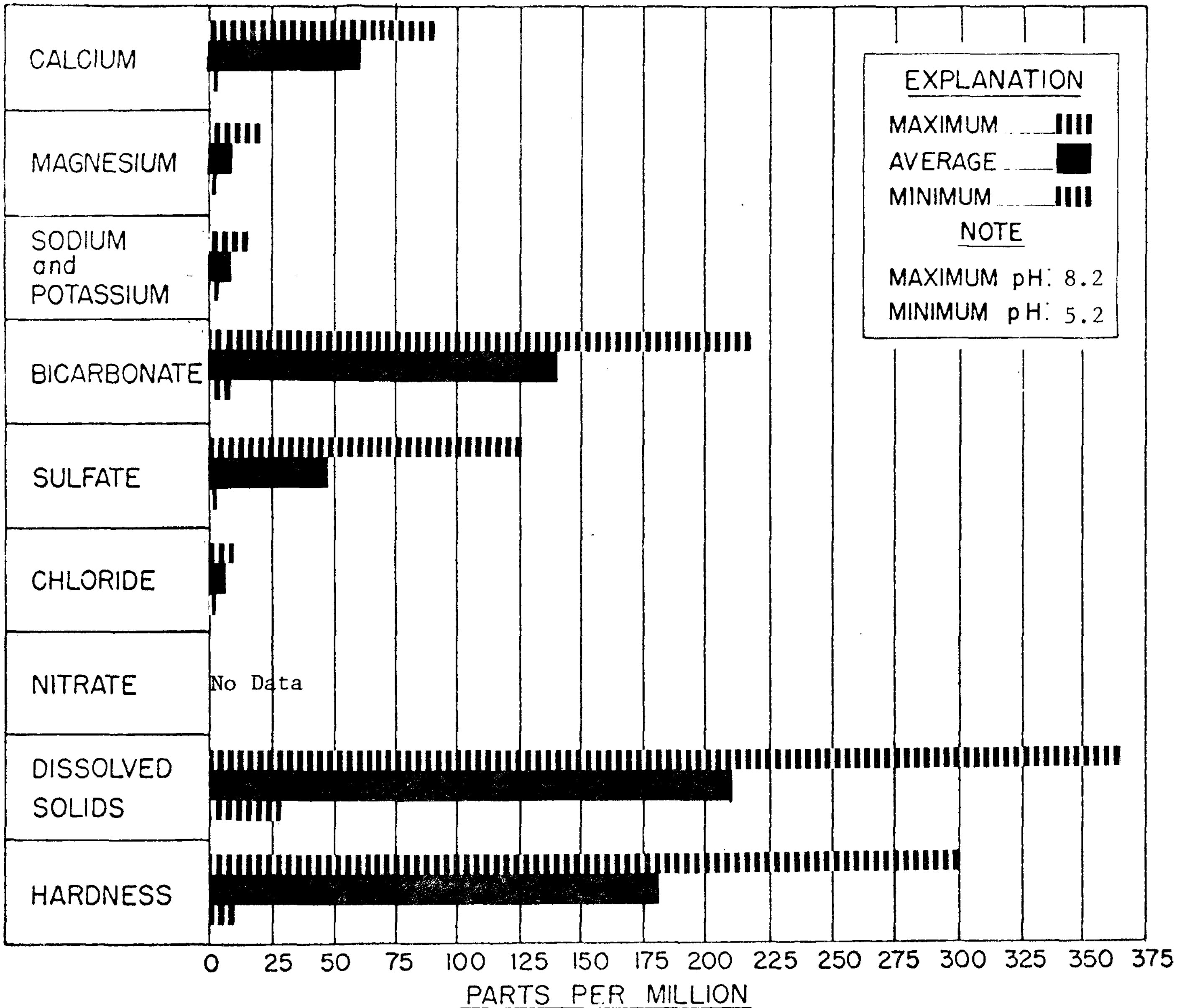
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE H-10

Eagle Creek

Glencoe

1-75 to 11-75



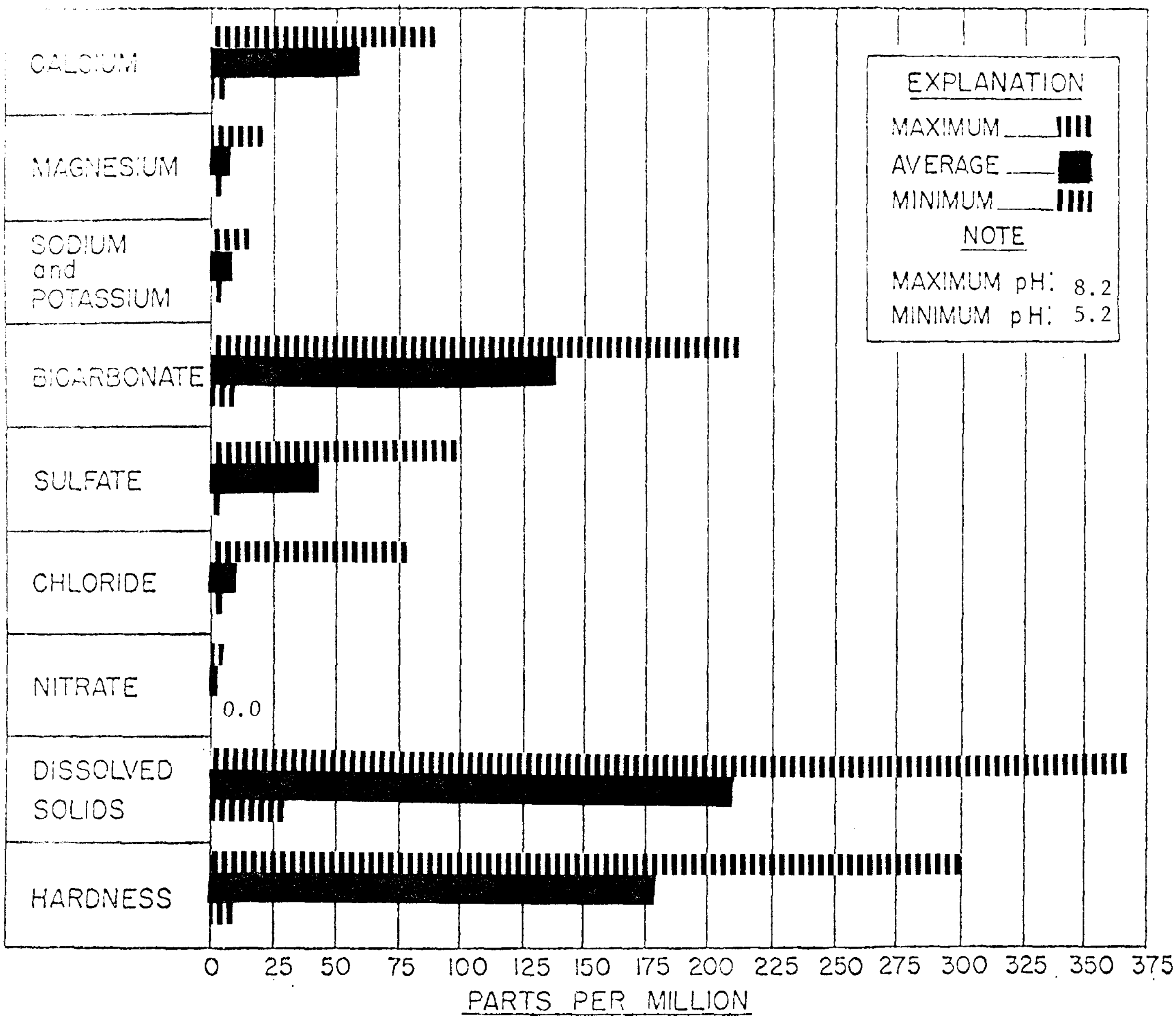
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE H-11

Eagle Creek

Glencoe

2-73 to 11-74



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE H-12

Eagle Creek

Glencoe

1-62 to 11-74

of less than 60 mg/l). The data studied indicates that the water in the Red River sub-basin is of the highest quality throughout the entire Kentucky River Basin.

The water quality of the main stem of the Kentucky River is demonstrated in Figures H-6 and H-7. This data was collected at Lock 4 near Frankfort and the river at this point is relatively insensitive due to its large drainage basin representation. This means that large influences are required to change the values measured in water quality. This data shows influences from upstream activities by an increase in dissolved solids and an increase in the hardness of the water. The hardness in the main stem is characterized as moderately hard (calcium bicarbonate hardness of 60 - 120 mg/l).

The North Fork of the Kentucky River at Hazard is just downstream of an intensive coal mining area and demonstrates the effects of such on water quality as can be seen in Figures H-2 and H-3 The North Fork is a relatively sensitive station showing a more rapid change in water quality. The water quality has been degraded by an increase in dissolved solids, hardness, sulfate, magnesium, calcium, sodium and potassium. The chloride levels are high as well as the sodium and potassium levels. This can be attributed to materials related to the coal mining industry. The acidity has increased as demonstrated by a decrease in pH. In general the water quality at this station is regarded as poor.

C. Trace Chemical Water Quality

Trace elements (under 5 mg/l) are separated from the general chemical background of this report because of their influence on human health. Generally, these materials are "heavy" metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State-Federal Water Quality Standards.

The trace elements measured in the Kentucky River Basin were less than the Kentucky/Federal Standards for Drinking water with the following exceptions. The station on the North Fork at Hazard yielded data that exceeded Kentucky/Federal Water Quality Standards in the parameters of iron, manganese, and lead. These parameters can be directly or indirectly related to coal mining activities. The standard for lead was surpassed three times at the Frankfort station and is under consideration for an intensive survey. The present analytical procedure is to be modified to yield the dissolved trace element values to reflect drinking water standards data.

D. Waste Load Effects on Water Quality

Within the confines of this report, water quality is considered as affected when the dissolved oxygen concentration drops below 5 mg/l. Approximately 868 miles of stream length were studied under a model used to determine waste load allocations, developed in the Kentucky Continuing Planning Process for River Basin Management Planning. According to this data, approximately 150 miles of that stream length would have a dissolved oxygen concentration of less than 5 mg/l when the flow is equal to or less than the 10 year 7 day low flow. This is highly possible as the flow of many of the tributaries does drop to or below, the 10 year 7 day low flow. It is not predicted that the dissolved oxygen concentration in any segment of the main stem of the river will drop below 5 mg/l.

Of the 150 miles of stream length affected, approximately 124 miles or 83 per cent will be due to municipalities, and 26 miles due to other dischargers such as subdivisions, trailer parks, schools, etc. The waste loads causing this effect totaled approximately 32 million gallons per day (mgd) of discharges with 30 million of it contributed by municipalities and the remaining two million by other discharges.

E. Non-Point Source Effects

Non-point source effects can be summarized in the three categories of agriculture, mining and surface runoff. It is estimated that approximately 1,070 square miles of disturbed forest land, cropland, and field gullies and some 1,700 miles of streambank and roadbank erode excessively and contribute to sediment in the streams. It is further estimated that over 54 square miles of surface mined land is exposed and has an excessive erosion rate.

Surface runoff from urban areas is also a problem in cases where sizable cities are located on low flow streams. There are three such cases in the Kentucky River Basin at the cities of Lexington, Richmond and Danville. This type of source exerts a load on the receiving stream with respect to Biochemical Oxygen Demand (BOD) and suspended solids.

F. Water Uses

The most important use of water is for public water supply. Over 51 million gallons per day is withdrawn for use in this basin. Of this amount, approximately 24 million gallons per day or 48 per cent is used for public supply. The remaining 27 million gallons per day is used for industry. It should be noted that 27 percent, or fourteen million gallons per day, of the total withdrawal is withdrawn from groundwater.

Another major use of water in this basin is for recreational purposes. There are numerous boat docks, camp sites, beaches and other recreational facilities located in the Kentucky River Basin. Furthermore, according to the Kentucky Department of Fish and Wildlife, there are over 2,000 miles of stream in this basin capable of providing a sport fishery with a grand total of 99 species of fishes representing 18 families.

Generally, water in the basin is widely used in the agricultural industry primarily for livestock watering with a small amount used for irrigation. The water in the basin is of sufficient quality for this use except in areas of extensive coal mining, i.e., in the headwaters.

G. Water Quality Changes

In general, the quality of the water in the Kentucky River Basin is not changing according to the data studied. However, the data taken at the station on the North Fork of the Kentucky River at Hazard reveals that the quality of the water is deteriorating. The concentrations of no less than nine of the parameters studied have increased by considerable amounts. With the energy crisis demanding greater and greater amounts of coal, there is the potential for these problems to increase even more. Much care must be taken in this area to prevent the quality of the water from deteriorating as coal production increases and an effort must be made to upgrade the existing quality of the water.

III. Summary

As stated earlier in this report, the quality of the water in the Kentucky River Basin is good at the station on the main stem of the river at Lock 4 near Frankfort, on the Red River at Pine Ridge and on Eagle Creek at Glencoe. However, the station on the North Fork of the Kentucky River at Hazard reflects the effects of coal mining on water quality.

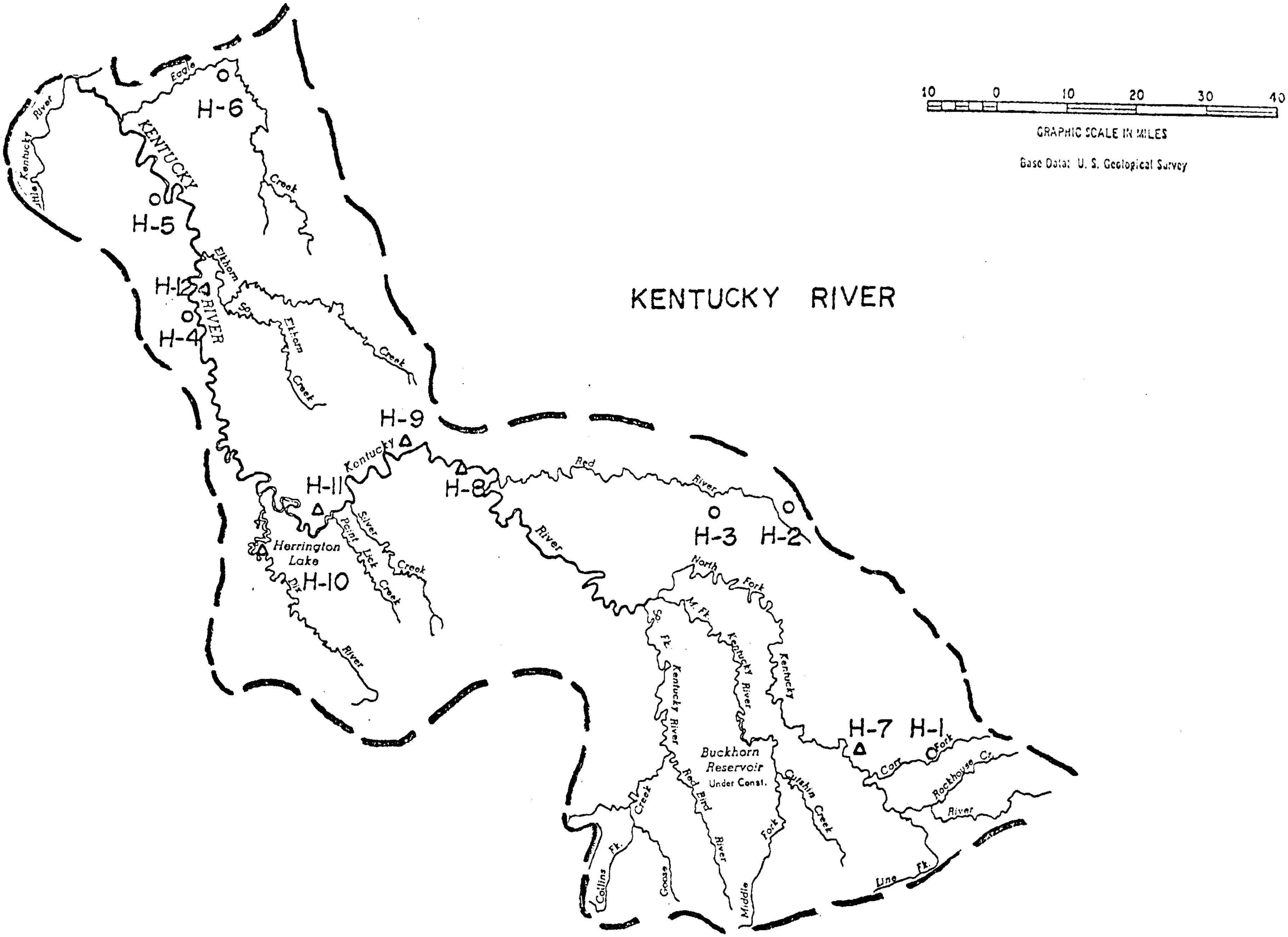
The two main problems in the basin with regards to water quality are siltation and municipal organic wasteloads.

The problem of municipal organic wasteloads is twofold: Inadequate treatment facilities and improper operation of some existing treatment facilities. More emphasis should be placed on the training of wastewater treatment plant operators and recruiting of better qualified personnel to insure proper operation and maintenance of treatment facilities. According to the data, 38 per cent of the existing treatment facilities in this basin need improvements as they are affecting the quality of the water.

The siltation and organic load problems related to urban runoff from sizeable cities located on low-flow streams can be improved by the installation of upgrading of storm sewer systems.

The siltation problem related to coal production is localized in the headwaters. The coal producing counties that contribute to this basin are Bell, Clay, Estill, Harlan, Knott, Knox, Leslie, Letcher and Perry. The logging of forest land in preparation for strip mining can result in high runoff rates and serious erosion while the actual strip mining leads to sedimentation from upheval of surface soil. With today's emphasis on increased coal production, this problem will have to be controlled to prevent further degradation of the water quality. As shown earlier in this report, the quality of the water is already below acceptable standards in this area and measures for improvement need to be emphasized and implemented.

The water quality problems related to coal production cannot be over emphasized. The State of Kentucky is the largest coal producing state in the nation and its production level is predicted to triple within the next few years. This amount of coal mining activity could have a disasterous, practically irreversible effect on the quality of the waters of Kentucky.


KENTUCKY RIVER
10 0 10 20 30 40
GRAPHIC SCALE IN MILES
Base Data: U. S. Geological Survey
H-1
H-2
H-3
H-4
H-5
H-6
H-7
H-8
H-9
H-10
H-11
H-12
KENTUCKY
RIVER
Kentucky River
Eagle
Creek
Elkhorn
So.
Elkhorn
Creek
Kentucky
Red
River
River
Silver
Creek
Point
Lick
Creek
Herrington
Lake
Dix
River
North
Fork
M. Fk.
Kentucky
River
Kentucky
So.
Fk.
Kentucky River
Buckhorn
Reservoir
Under Const.
Cutshin
Creek
Red Bird
River
Middle
Fork
Goose
Creek
Collins
Fk.
Carr
Fork
Rockhouse Cr.
River
Line
Fk.

STATION KEY

H-1	CARR FORK NEAR SASSAFRAS
H-2	RED RIVER NEAR HAZEL GREEN
H-3	RED RIVER NEAR PINE RIDGE
H-4	KENTUCKY RIVER AT LOCK 4
H-5	KENTUCKY RIVER AT LOCK 2
H-6	EAGLE CREEK AT GLENCOE
H-7	NORTH FORK KENTUCKY RIVER AT HAZARD
H-8	KENTUCKY RIVER AT RICHMOND
H-9	KENTUCKY RIVER AT LEXINGTON WPI
H-10	DIX RIVER AT DANVILLE WPI
H-11	KENTUCKY RIVER AT LOCK 8
H-12	KENTUCKY RIVER AT FRANKFORT WPI

TABLE H-1

SUB-BASINS OF 200 SQUARE MILES OR GREATER IN

THE KENTUCKY RIVER BASIN

Sub-basins	Square Miles
North Fork of Kentucky	1,883.0
South Fork of Kentucky	748.0
Middle Fork of Kentucky	559.0
Red River	487.00
Dix River	442.0
Elkhorn Creek (at lower Dam Site) Mile 2.5	492.0
Eagle Creek	519.0
Station Cam Creek	217.0

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e River Basin Planning Effort.

TABLE H-2

COUNTY AREA IN THE KENTUCKY RIVER BASIN

County	Total Area (sq. miles)	Area in Basin (sq. miles)	County	Total Area (sq. miles)	Area in Basin (sq. miles)
Anderson	206	70	Lee	210	210
Bell	370	15	Leslie	409	409
Boyle	183	80	Letcher	339	290
Breathitt	494	494	Lincoln	340	187
Carroll	130	86	Madison	446	446
Clark	259	130	Menifee	210	65
Clay	474	430	Mercer	256	102
Estill	260	260	Montgomery	204	35
Fayette	280	280	Owen	351	351
Franklin	211	211	Owsley	197	197
Garrard	236	236	Perry	341	341
Grant	249	249	Powell	173	173
Harlan	469	70	Rockcastle	311	60
Henry	289	260	Scott	284	284
Jackson	337	135	Shelby	383	70
Jessamine	177	177	Trimble	146	60
Knott	356	255	Wolfe	227	227
Knox	373	38	Woodford	193	193
			Total		7,033

SOURCE: Rand McNally Standard Reference Map and Guide of Kentucky, 1972.

TABLE H-3

SLOPES AND ELEVATIONS OF PRINCIPAL TRIBUTARIES IN THE KENTUCKY RIVER BASIN

STREAM	LENGTH (Miles)	Max. El. (m.s.l.)	Min. El. (m.s.l.)	AVERAGE SLOPE (ft./miles)
N. Fork of Kentucky River	148.1	1,109	634	3.21
M. Fork of Kentucky River	43.3	757	627	3.00
S. Fork of Kentucky River	85.0	1,250	634	7.25
Goose Creek	21.8	830	754	3.49
Troublesome Creek	42.4	1,004	720	6.69
Red River	59.5	713	566	2.47
Otter Creek	13.1	880	566	23.97
Boone Creek	7.2	780	549	32.08
Silver Creek	39.2	936	531	10.33
Paint Lick Creek	32.0	920	531	12.16
Hickman Creek	31.5	910	514	12.57
Jessamine Creek	13.1	860	519	26.03
Clarks Run Creek	10.4	920	750	16.35
Dix River H.W. to mp 34.6	23.2	822	750	3.27
	0.0 slope from mp 34.60 to mouth including reservoir			
Glenns Creek	12.5	830	469	28.88
Elkhorn Creek	90.6	950	454	5.48
Drennon Creek	16.6	800	428	22.41
Stephens Creek	20.9	920	598	15.41
Clarks Creek	15.4	791	586	13.31
Eagle Creek	81.4	737	428	3.80
Little Eagle Creek	12.6	914	737	14.05

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e River Basin Planning Effort.

TABLE H-5

LAKES IN THE KENTUCKY RIVER BASIN

Location	County	Surface Area (Acres)	Capacity Acre-Feet
Fishpond Lake	Letcher County	31	1,037
Taylor Fork Lake	Madison County	169	3,572
Corinth Lake	Grant County	96	1,612
Bullock Pen	Grant County	134	2,464
Elmer Davis Lake	Owen County	149	3,151
Pan Bowl Lake	Jackson County	98	1,298
Lexington Reservoirs	Fayette County	408	3,850
Mill Creek Lake	Wolfe County	41	1,049
Elk Lake	Owen County	207	2,654
Herrington Lake	Mercer County	2,940	230,500
Kentucky Utility Fly Ash Disposal	Carroll County	89	2,491
Lake Vega	Madison County	132	1,557
Boltz Lake	Grant County	92	2,168
Total	---------------------	4,586	257,403
Federal			
Buckhorn Lake	Leslie & Perry County	1,230	21,800
Carr Fork Lake	Knott County	710	6,480
Total	---------------------	1,940	28,280
Grand Total	---------------------	6,526	285,683

SOURCE: Kentucky Department for Natural Resources and Environmental Protection, Division of Water Resources.

Table H-6

City Population and Facility Grant Status
in the Kentucky River Basin in Kentucky

County	City	Population	Project Type	Comments
Anderson				
Bell				
Boyle	Danville (Junction City)	12,400 1,046	1	Active
Breathitt	Jackson	1,887	1	Active
Carroll	Carrollton	3,884	1	Active
Clark				
Clay	Manchester	1,664	1	Active
Estill	Irvine (Ravenna)	2,918 734	1	Active
Fayette	Lexington-Main (Lexington-West Hickman)	73,500 43,500	1	Active
Franklin	Frankfort	22,700	1 & 2	Active
Garrard	Lancaster	3,230	1	Active
Grant	Williamstown (Dry Ridge)	2,063 1,100	1 2 3	Active Pending Active
Harlan				
Henry	New Castle Pleasureville	755 747	1 1	Active Active
Jackson				
Jessamine	Nicholasville Wilmore	5,829 3,466	1 None	Active Sewers/STP
Knott	Hindman	808	1	Active
Knox				
Lee	Beattyville	923	1	Active

Table H-6
Continued

County	City	Population	Project Type	Comments
Leslie	Hyden	482	None	Sewers/STP
Letcher	Whitesburg	1,137	1	Active
	Sanitation District #1 (Neon-Fleming)	1,178	1 & 2	Active
Lincoln	Stanford	2,474	1	Active
	Crab Orchard	861	1	Active
	Hustonville	413	1	Active
Madison	Berea #1	4,600	1	Active
	(Berea #2)	2,300		
	Richmond #1	10,100	1	Active
			2	Pending
	(Richmond #2)	7,700		
Menifee				
Mercer	(Burgin)	1,002	1	Active
Montgomery				
Owen	Owenton	1,280	1	Active
Owsley	Booneville	126	None	Sewers/STP
Perry	Hazard	5,459	1	
	(Sanitation District #1) Vicco	377	1	Active
Powell	Stanton	2,037	1	Active
	(Clay City)	983		
Rockcastle	Brodhead	769	None	Sewers/STP
Scott	Georgetown	8,629	1	Underway
	Stamping Ground	411	3	Active
	Sadieville	272	None	No Sewers
Shelby				
Trimble				

Table H-6
Continued

County	City	Population	Project Type	Comments
Wolfe	Campton	419	1	Active
	Wolfe County W. D.	200	1	Active
Woodford	Versailles	5,679	1	Active
	Midway	1,278	1	Active

NOTE: Project type is related to the grant process step applied for or active for each municipality. Step 1 is the preliminary studies (201 Facilities Plan) required before design of the facilities. Step 2 is the design phase of the project, and Step 3 is the construction of facilities for the collection and treatment of wastewaters.

The comments relate to the status of the grant. Active indicates the project is funded and underway. Pending indicates that application for a grant has been made and is pending approval. No sewers indicates that the municipality does not presently have a comprehensive sewer system. Sewers/STP indicates the municipality is now served by sewers and treatment facilities.

The source of this information was the 1970 U. S. Census and the FY 77 construction grants list for Kentucky.

TABLE H-7

Organic Loads Affecting Streams in the Kentucky River Basin

Length of streams to which treated organic loads are discharged		868
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow		145
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow due to	Municipal Discharges	119
	Industrial Discharges	---
	Other Discharges	26

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e river basin planning effort. The values indicated the stream miles in which the dissolved oxygen is predicted to be less than 5 mg.l when the stream flow is less than the once in ten year, seven day, low flow.

Table H-8

LOCKS AND DAMS ON THE KENTUCKY RIVER

Lock No.	Miles Above Mouth	Length of Pool Above Dam (miles)
1	4.0	27.0
2	31.0	11.0
3	42.0	23.0
4	65.0	17.2
5	82.2	14.0
6	96.2	20.8
7	117.0	22.9
8	139.9	17.6
9	157.5	18.9
10	176.4	24.6
11	201.0	19.9
12	220.9	19.0
13	239.9	9.1
14	249.0	-

Navigation Charts
U. S. Army Corps of Engineers
Louisville District

Table H-9

Water Quality Data for the Kentucky River Basin

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
STORET #00400	pH Specific Units	Kentucky Standard 6-LT pH LT 9					
Carr Fork near Saasafras							
U.S.G.S. 03277450	70/07/07	74/07/16	7.18	8.0	6.4	33	.360
North Fork Kentucky	75/01/16	75/01/16	7.4			1	
River at Hazard	70/01/31	74/06/11	7.4	8.2	6.2	91	.413
U.S.G.S. 0327750	65/01/07	75/01/16	7.3	8.2	3.8	210	.530
	62/01/08	74/06/--	7.2	9.5	3.8	276	0.7
Red River near							
Hazel Green							
U.S.G.S. 03282500	70/10/02	72/09/12	7.1	7.3	6.8	3	.289
Red River near	71/01/13	74/07/08	7.1	7.8	6.7	33	.237
Pine Ridge	69/08/08	70/11/04	7.3	7.7	6.7	13	.326
U.S.G.S. 03283100	69/03/20	69/03/05	7.5	7.5	7.5	2	.00
Kentucky River Lock 4	70/01/02	73/09/26	7.6	8.1	6.8	92	.308
U.S.G.S. 03287500	65/01/13	73/09/26	7.5	8.4	6.7	208	.334
	59/10/25	73/09/26	7.5	8.4	5.2	206	.370
Kentucky River Lock 2	76/01/07	76/11/02	6.79	7.5	6.1	11	0.461
U.S.G.S. 03290500	73/02/07	76/11/02	7.1	7.8	6.1	40	0.466
Eagle Creek at Glencoe	75/07/14	75/07/14	7.7			1	
U.S.G.S. 03291500	70/08/06	74/10/07	7.6	8.1	7.0	39	.267
	62/01/25	74/10/07	7.6	8.1	7.0	41	.263
STORET #00095	Conductivity Micromhos, Kentucky Standard 800 micromhos						
Carr Fork near	76/01/28	76/09/02	269.2	354.0	215.0	6	57.0
Sassafras	70/07/07	76/09/02	294.2	554.0	84.0	56	100.4
North Fork Kentucky	75/01/16	75/01/16	271.0			1	
River at Hazard	70/01/31	74/06/11	392.4	946.0	100.0	93	197.5
	62/10/08	74/06/11	7.2	8.2	3.8	264	.599
Red River near	76/01/16	76/08/17	82.5	120.0	60.0	4	26.29
Hazel Green	70/10/02	76/08/17	109.28	157.0	60.0	7	39.42
Red River near	76/01/16	76/08/17	75.0	100.0	65.0	5	14.57
Pine Ridge	68/11/21	76/08/17	97.34	160.0	57.99	72	27.52

Table H-9
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
Kentucky River Lock 4	75/03/14	75/03/14	210.0			1	
	70/01/02	74/08/26	258.1	646.0	115.0	96	98.3
	65/01/13	74/08/26	265.4	675.0	115.0	222	104.4
	59/10/03	74/08/26	253.0	675.0	76.0	388	94.9
Kentucky River Lock 2	76/01/07	76/12/01	254.2	320.0	195.0	12	39.01
	73/02/07	76/12/01	246.77	336.0	123.0	45	38.29
Eagle Creek at Glencoe	75/01/30	75/11/07	436.0	160.0	10.0	7	101.5
	70/08/06	74/12/09	365.8	617.0	204.0	48	85.6
	70/08/06	74/12/09	365.8	617.0	204.0	48	85.6
	62/01/25	74/12/09	361.2	617.0	204.0	50	86.8
STORET #70300	Dissolved Solids Milligrams/liter KY. Std. 500 mg/l						
Carr Fork near Sassafras	76/01/28	76/09/02	163.5	226.0	114.0	6	45.3
	70/07/07	76/09/02	187.4	326.0	48.0	56	63.4
North Fork Kentucky River at Hazard	70/01/31	74/06/11	259.3	676.0	58.0	91	141.1
	65/01/07	74/06/11	267.9	810.0	58.0	219	147.5
	62/10/08	74/06/11	290.8	1800.0	58.0	294	188.7
Red River near Hazel Green	70/10/02	72/09/12	90.0	100.0	74.0	3	14.0
Red River near Pine Ridge	76/01/16	76/08/17	46.6	52.0	36.0	5	6.69
	69/03/20	76/08/17	62.01	95.9	30.0	71	16.1
Kentucky River Lock 4	70/01/02	73/09/26	158.5	400.0	54.0	92	60.5
	65/01/13	73/09/26	162.6	400.0	54.0	218	62.8
	59/10/03	73/09/26	150.2	400.0	8.2	414	55.5
Kentucky River Lock 2	76/01/07	76/11/02	149.8	169.0	128.0	11	14.39
	73/02/07	76/11/02	154.47	220.0	96.0	47	23.41
Eagle Creek at Glencoe	75/01/30	75/12/18	260.0	368.0	184.0	7	63.6
	70/08/06	74/12/09	231.6	385.0	136.0	48	54.6
	70/08/06	74/12/09	231.6	385.0	136.0	48	54.6
	62/01/25	74/12/09	229.0	385.0	136.0	50	55.0
STORET #00410	Alkalinity mg/l No Standard						
Carr Fork near Sassafras	76/01/28	76/09/02	50.3	94.0	25.0	6	27.1
	70/07/07	76/09/02	54.7	201.0	11.0	56	38.1

Table H-9
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
North Fork Kentucky	75/01/16	75/01/16	43.0			1	
Hazard	70/01/31	74/06/11	52.0	125.0	8.0	91	29.4
	62/12/20	74/06/11	49.2	125.0	.00	170	38.6
	65/01/07	74/06/--	55.0	205.0	0.0	177	42.0
Red River near Hazel Green	70/10/02	72/09/12	43.7	54.0	34.0	3	10.01
Red River near	76/01/16	76/08/17	16.6	25.0	11.0	5	5.4
Pine Ridge	69/03/20	76/08/17	26.6	54.0	9.0	71	12.45
Kentucky River Lock 4	70/01/02	73/09/26	65.4	156.0	28.0	92	20.5
	65/01/13	73/09/26	65.4	156.0	28.0	166	18.8
	59/10/25	73/09/26	65.0	156.0	16.0	229	20.0
Kentucky River Lock 2	76/01/07	76/11/02	71.64	83.0	57.0	11	7.32
	73/02/07	76/11/02	76,66	110.0	28.0	47	14.57
Eagle Creek at	75/01/30	75/12/18	153.1	232.0	112.0	9	38.5
Glencoe	70/08/06	74/12/09	142.5	217.0	78.0	48	32.5
STORET #00900	Hardness mg/1, 0-60 Soft, 61-120 moderately hard, 121-180 hard, over 180 very hard						
Carr Fork near	76/01/28	76/09/02	106.7	140.0	81.0	6	21.5
Sassafras	70/07/07	76/09/02	120.6	233.0	36.0	56	40.6
North Fork Kentucky	70/01/31	73/09/15	148.5	370.0	12.0	90	78.9
River, Hazard	65/01/07	73/09/15	148.2	422.0	12.0	208	79.1
	62/10/08	73/09/15	157.9	1090.0	12.0	257	107.2
Red River near Hazel Green	70/10/02	72/09/12	59.0	71.0	48.0	3	11.5
Red River near	76/01/16	76/08/17	28.4	36.0	24.0	5	4.62
Pine Ridge	69/03/20	76/08/17	38.68	62.0	18.0	70	11.83
Kentucky River Lock 4	70/01/02	73/09/26	104.5	190.0	49.0	92	31.7
	65/01/13	73/09/26	104.7	192.0	48.0	208	30.8
	59/10/03	73/09/26	99.2	192.0	21.0	381	28.9

Table H-9
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
Kentucky River Lock 2	76/01/07	76/11/02	109.3	120.0	93.0	11	8.97
	73/02/07	76/11/02	111.62	150.0	56.0	47	15.72
Eagle Creek at Glencoe	75/01/30	75/12/18	208.9	320.0	140.0	9	54.4
	70/08/06	74/12/09	185.0	300.0	94.0	48	47.1
	62/01/25	74/12/09	182.4	300.0	94.0	50	47.8
STORET #00080	Color Platinum - Cobalt Units, Prop. EPA Std. 75 Units						
Carr Fork near Sassafras	76/01/28	76/09/02	54.2	140.0	0.0	6	63.3
	70/07/07	76/09/02	69.1	1200.0	0.0	55	186.8
North Fork Kentucky River at Hazard	70/11/03	72/10/15	8.3	15.0	.00	3	7.6
	65/01/07	72/10/15	8.2	50.0	.00	68	9.0
	62/10/08	72/10/15	7.9	50.0	.00	117	8.4
Red River near Pine Ridge	76/01/16	76/08/17	14.0	25.0	5.0	5	8.22
	69/03/20	76/08/17	14.6	70.0	0.0	68	12.83
Kentucky River Lock 4	70/10/07	72/10/21	6.6	10.0	.00	3	5.8
	65/01/13	72/10/21	8.0	50.0	.00	65	8.2
	59/10/25	72/10/21	8.9	50.0	.00	138	7.8
Eagle Creek at Glencoe	75/01/30	75/12/18	47.9	160.0	10.0	9	48.6
	70/08/06	74/12/09	49.2	300.0	5.0	45	52.8
	62/01/25	74/12/09	48.5	300.0	5.0	47	51.7
STORET #00930	Sodium mg/l, No Standard						
Carr Fork near Sassafras	76/01/28	76/09/02	10.0	15.0	5.4	6	4.1
	70/07/07	76/09/02	10.7	52.0	1.6	56	8.4
North Fork Kentucky River at Hazard	70/11/03	72/10/15	38.0	56.0	26.0	3	15.9
	65/07/25	72/10/15	38.2	60.0	17.0	9	18.9
Red River near Pine Ridge	76/01/16	76/08/17	2.12	2.9	1.9	5	.44
	69/03/20	76/08/17	2.9	6.2	1.4	70	1.02
Kentucky River Lock 4	70/10/07	72/10/21	42.3	56.0	34.0	3	11.0
	67/07/27	72/10/21	42.2	56.0	33.0	6	10.5
	59/10/25	72/10/21	17	56.0	4.1	17	18.3

Table H-9
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
Kentucky River Lock 2	76/01/07	76/11/02	7.7	12.0	3.7	11	3.37
	73/02/07	76/11/02	6.6	16.0	2.3	47	3.08
Eagle Creek at Glencoe	75/01/30	75/12/18	6.2	11.0	3.5	9	2.24
	70/08/06	74/12/09	4.6	9.1	1.7	47	1.72
	62/01/25	74/12/09	4.5	9.1	1.7	49	1.77
STORET #00934	Potassium mg/l, No Standard						
Carr Fork near Sassafras	76/01/28	76/09/02	2.3	3.0	1.60	6	0.579
	70/07/07	76/09/02	2.8	5.8	1.4	56	0.985
North Fork Kentucky River at Hazard	70/11/03	72/10/15	5.8	8.0	3.4	3	2.31
	65/07/25	72/10/15	5.3	8.0	3.4	6	1.70
Red River near Pine Ridge	76/01/16	76/08/17	1.34	1.8	1.0	5	0.38
	69/03/20	76/08/17	1.91	4.2	1.0	70	0.77
Kentucky River Lock 4	70/10/07	72/10/21	3.9	4.6	3.4	3	.611
	67/07/27	72/10/21	3.4	4.6	2.7	6	.713
	59/10/25	72/10/21	2.6	4.6	1.6	17	.801
Kentucky River Lock 2	76/01/07	76/11/02	2.16	2.9	1.3	11	0.609
	73/02/07	76/11/02	2.3	3.7	1.3	47	0.687
Eagle Creek near Glencoe	74/01/30	75/12/18	3.0	4.0	1.9	9	.813
	70/08/06	74/12/09	3.4	5.8	1.7	47	1.10
	62/01/25	74/12/09	3.4	5.8	1.7	49	1.10
STORET #00940	Chloride mg/l, Prop. EPA Standard 250 mg/l						
Carr Fork near Sassafras	76/01/28	76/09/02	3.7	7.3	2.3	6	1.80
	70/07/07	76/09/02	4.3	13.0	1.0	56	2.69
North Fork Kentucky near Hazard	75/01/16	75/01/16	7.3			1	
	70/01/31	73/09/15	6.2	36.0	1.5	90	5.09
	62/10/08	73/09/15	7.7	40.0	.00	257	6.31
Red River near Hazel Green	70/10/02	72/09/12	6.3	6.7	5.7	3	.513

Table H-9
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
Red River near Pine Ridge	76/01/16	76/08/17	2.18	2.9	1.6	5	0.59
	69/03/20	76/08/17	3.8	8.0	1.1	70	1.69
Kentucky River Lock 4	70/01/02	73/09/26	16.0	130.0	1.9	92	20.1
	65/01/13	73/09/26	19.7	130.0	1.9	208	23.7
	59/10/25	73/09/26	19.6	130.0	1.9	283	22.9
Kentucky River Lock 2	76/01/07	76/11/02	10.77	20.0	4.8	11	5.42
	73/02/07	76/11/02	9.5	29.0	3.1	47	4.98
Eagle Creek at Glencoe	75/01/30	75/12/18	7.3	18.0	3.0	8	4.44
	70/08/06	74/12/09	8.0	80.0	2.3	48	10.9
	62/01/25	74/12/09	7.7	80.0	1.0	50	10.7
STORET # 00945	Sulfate (mg/l), Prop. EPA Standard 250 mg/l						
Carr Fork near Sassafras	76/01/28	76/09/02	66.8	79.0	50.0	6	11.4
	70/07/07	76/09/02	80.1	186.0	23.0	56	25.5
North Fork Kentucky River at Hazard	75/01/16	75/01/16	71.0			1	
	70/01/31	74/06/11	132.2	340.0	13.0	91	74.4
	62/10/08	74/06/11	150.6	997.0	13.0	258	108.1
Red River near Hazel Green	70/10/02	72/09/12	16.7	19.0	13.0	3	3.2
Red River near Pine Ridge	76/01/16	76/08/17	13.2	14.0	13.0	5	0.45
	69/03/20	76/08/17	14.1	22.	9.2	71	2.5
Kentucky River Lock 4	70/01/02	73/09/26	37.8	89.0	18.0	92	13.2
	65/01/13	73/09/26	35.8	89.0	17.0	208	12.0
	59/10/25	73/09/26	34.0	89.0	13.0	283	11.9
Kentucky River Lock 2	76/01/07	76/11/02	35.18	44.0	30.0	11	5.56
	73/02/07	76/11/02	32.72	51.0	21.0	47	6.92
Eagle Creek at Glencoe	75/01/30	75/12/18	53.1	91.0	35.0	8	17.7
	70/08/06	74/12/09	43.5	100.0	19.0	48	15.9
	62/01/25	74/12/09	42.7	100.0	19.0	50	16.2

Table H- 9
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
Eagle Creek at Glencoe	75/01/30	75/12/18	.27	.60	.10	9	.141
	70/08/06	74/12/09	.29	1.1	.10	48	.188
	62/01/25	74/12/09	.294	1.1	0.1	50	.189
STORET #00915	Calcium, Milligrams/liter, No Standard						
Carr Fork near Sassafras	76/01/28	76/09/02	26.2	35.0	18.0	6	5.9
	70/07/07	76/09/02	29.3	57.0	7.7	56	11.1
North Fork Kentucky River at Hazard	70/11/03	72/10/15	60.0	72.0	38.0	3	19.1
	68/10/13	72/10/15	73.4	131.0	38.0	5	35.0
Red River near Pine Ridge	76/01/16	76/08/17	7.44	9.4	6.3	5	1.28
	69/03/20	76/08/17	10.09	17.0	3.5	70	3.49
Kentucky River Lock 4	70/10/07	72/10/21	46.3	50.0	42.0	3	4.04
	68/12/11	72/10/21	50.4	47.0	42.0	5	6.27
	59/10/25	72/10/21	36.7	57.0	21.0	19	11.1
Kentucky River Lock 2	76/01/07	76/11/02	33.1	39.0	27.0	11	3.36
	73/02/07	76/11/02	33.96	47.0	15.0	47	5.32
Eagle Creek at Glencoe	75/01/30	75/12/18	64.8	94.0	46.0	9	15.8
	70/08/06	74/12/09	60.3	88.0	29.0	47	14.4
	62/01/24	74/12/09	59.6	88.0	29.0	49	14.7
STORET #00925	Magnesium, mg/l, No Standard						
Carr Fork near Sassafras	76/01/28	76/09/02	10.2	12.0	7.6	6	1.78
	70/07/07	76/09/02	11.6	22.0	3.5	56	3.55
North Fork Kentucky River at Hazard	70/11/03	72/10/15	25.3	29.0	20.0	3	4.73
	68/10/13	72/10/15	24.0	29.0	20.0	5	3.87
Red River near Pine Ridge	76/01/16	76/08/17	2.4	3.0	2.0	5	.381
	69/03/20	76/08/17	3.27	6.3	1.7	70	.949
Kentucky River Lock 4	70/10/07	72/10/21	13.0	14.0	11.0	3	1.73
	68/12/11	72/10/21	12.6	14.0	11.0	5	1.34
	59/10/25	72/10/21	7.5	14.0	3.1	19	3.38

Table H-9
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
STORET #00618	Nitrate - N mg/l, Prop. EPA Standard 10 mg/l						
Carr Fork near Sassafras	76/01/28	76/09/02	0.20	0.37	0.02	6	0.155
	71/10/19	76/09/02	0.34	4.5	0.0	44	0.669
North Fork Kentucky at Hazard	71/10/18	73/09/15	.54	2.2	.10	50	.329
Red River near Hazel Green	72/09/12	72/09/12	1.1			1	
Red River near Pine Ridge	76/01/16	76/08/17	0.254	0.49	0.14	5	0.138
	71/10/27	76/08/17	0.176	0.50	0.00	45	0.133
Kentucky River Lock 4	71/10/06	73/09/26	.70	1.2	.40	49	.189
Eagle Creek at Glencoe	75/01/30	75/12/18	.35	.66	.01	8	.224
	71/10/14	74/12/09	.40	1.1	.00	33	.351
STORET #00950	Fluoride mg/l Prop. EPA Standard 1.0 mg/l						
Carr Fork near Sassafras	76/01/28	76/09/02	0.13	0.20	0.10	6	0.05
	70/07/07	76/09/02	0.17	0.70	0.00	56	0.11
North Fork Kentucky River at Hazard	70/09/16	73/03/30	.45	3.7	.10	12	1.02
	68/10/13	73/03/30	.41	3.7	.10	14	.94
Red River near Hazel Green	70/10/02	72/09/12	.10	.10	.10	3	.00
Red River near Pine Ridge	76/01/16	76/08/17	0.14	0.20	0.10	5	0.055
	69/03/20	76/08/17	0.13	0.40	0.00	70	0.094
Kentucky River Lock 4	70/10/07	72/10/21	.17	.30	.10	6	.082
	67/07/27	72/10/21	.18	.30	.10	9	.067
	59/10/25	72/10/21	.21	.40	.10	18	.073
Kentucky River Lock 2	76/01/07	76/11/02	.20	.30	.00	11	.077
	73/02/07	76/11/02	.199	.50	.00	47	.099

Table H-9
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
Kentucky River Lock 2	75/01/07	75/12/04	6.6	8.4	5.4	12	1.08
	73/02/07	74/12/09	6.4	11.0	3.9	24	1.57
Eagle Creek at Glencoe	75/01/30	75/12/18	11.4	21.0	6.8	9	4.16
	70/08/06	74/12/09	8.7	20.0	4.2	47	3.25
	62/01/25	74/12/09	8.5	20.0	4.2	49	3.3
STORET #01025	Cadium, micrograms/liter, Kentucky Standarg, 100 ug/l						
North Fork Kentucky River at Hazard	75/03/20	75/06/17	.33	1.0	.00	3	.577
	74/04/16	74/10/03	1.25	4.0	.00	4	1.89
	63/10/25	74/10/03	.50	4.0	.0	10	1.27
Red River near Hazel Green	76/01/16	76/08/17	1.75	6.0	.00	4	2.87
	75/07/08	76/08/17	1.33	6.0	.00	6	2.33
Kentucky River Lock 4	75/01/22	75/04/21	.67	1.0	.00	3	.577
	74/03/11	74/09/30	1.0	6.0	.00	7	2.24
	62/11/12	74/09/30	.41	6.0	.00	17	1.46
Kentucky River Lock 2	76/01/07	76/10/07	1.00	2.0	.00	4	1.15
	73/04/17	76/10/07	1.44	7.0	.00	16	1.71
Eagle Creek at Glencoe	75/06/06	75/06/06	.00			1	
	74/03/16	74/12/09	2.7	7.0	.00	6	2.58
STORET # 01056	Manganese, micrograms/liter Prop. Standard 50 ug/l						
Carr Fork near Sassafras	76/01/28	76/09/02	160.0	360.0	20.0	6	124.42
	71/10/19	76/09/02	325.2	1200.0	5.99	43	197.72
North Fork Kentucky River at Hazard	74/04/16	74/04/16	83.0			1	
Red River near Pine Ridge	76/01/16	76/08/17	14.0	20.0	0.00	5	8.94
	69/03/20	76/08/17	32.1	180.0	0.00	65	32.19
Kentucky River Lock 4	75/04/21	75/04/21	40.0			1	
Kentucky River Lock 2	76/01/07	76/10/07	12.5	20.0	.00	4	9.57
	73/04/17	76/10/07	14.4	43.0	.00	16	13.22

Table H-9
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
Eagle Creek at Glencoe	75/01/30	75/12/18	14.0	40.0	.00	9	11.5
	71/10/14	74/12/09	32.5	180.0	.00	32	37.4
STORET #01046	Iron, micrograms/liter, EPA Standard 300 u g/l						
Carr Fork near Sassafras	76/01/28	76/09/02	56.66	140.0	.00	6	59.21
	71/10/19	76/09/02	101.80	859.99	.00	43	186.09
North Fork Kentucky River at Hazard	74/04/16	74/04/16	10.0			1	
	65/01/07	74/04/16	65.8	450.0	.00	19	116.6
	64/12/01	74/04/16	76.7	450.0	.00	21	116.5
Red River near Pine Ridge	76/01/16	76/08/17	12.0	30.0	0.00	5	13.038
	69/03/20	76/08/17	142.7	740.0	0.00	66	125.435
Kentucky River Lock 4	75/04/21	74/04/21	10.0			1	
Kentucky River Lock 2	76/01/07	76/10/07	10.0	30.0	.00	4	14.14
	73/04/17	76/10/07	23.13	90.0	.00	16	30.70
Eagle Creek at Glencoe	75/01/30	74/12/18	67.8	210.0	10.0	9	59.3
	71/10/14	74/12/09	95.6	280.0	10.0	32	66.2
STORET #01030	Chromium, micrograms/liter, EPA Stantard 300 ug/l						
North Fork Kentucky River at Hazard	75/03/20	75/06/17	.33	1.0	.00	3	.577
	74/04/16	74/10/03	.25	1.0	.00	4	.500
Red River near Hazel Green	76/01/16	76/08/17	4.50	18.0	.00	4	9.0
	75/07/08	76/08/17	3.00	18.0	.00	6	7.35
Kentucky River Lock 4	75/01/22	75/04/21	1.3	4.0	.00	3	2.31
	74/03/11	74/09/30	1.9	10.0	.00	7	3.63
Kentucky River Lock 2	76/01/07	76/10/07	2.0	8.0	.00	4	4.00
	73/04/17	76/10/07	.80	8.0	.00	15	2.04
Eagle Creek at Glencoe	75/06/06	75/06/06	1.0			1	
	74/03/16	74/12/09	.67	1.0	.00	6	.516

Table H-9
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
STORET #01049	Lead, micrograms/liter, Kentucky Standard 50 ug/l						
North Fork Kentucky River at Hazard	75/03/20	75/06/17	3.3	6.0	.00	3	3.06
	74/04/16	74/10/03	1.7	3.0	.00	3	1.53
	63/10/25	74/10/03	.556	3.0	.0	9	1.13
Red River near Hazel Green	76/01/16	76/08/17	2.25	5.0	.00	4	2.63
	75/07/08	76/08/17	3.16	7.0	.00	6	2.78
Kentucky River Lock 4	75/01/22	75/04/21	4.0	8.0	1.0	3	3.61
	74/03/11	74/09/30	8.0	20.0	1.0	7	6.30
	62/11/12	74/09/30	3.3	20.0	0.	17	5.60
Kentucky River Lock 2	76/01/07	76/10/07	2.5	6.0	.00	4	3.00
	73/04/17	76/10/07	2.94	6.0	.00	16	2.205
Eagle Creek at Glencoe	75/06/06	75/06/06	2.0			1	
	74/03/16	74/12/09	10.2	32.0	.00	6	12.6
STORET #01000	Arsenic, micrograms/liter, Kentucky Standard 50 ug/l						
North Fork Kentucky River at Hazard	75/03/20	75/06/17	.33	1.0	.00	3	.577
	74/04/16	74/10/03	.00	.00	.00	4	.000
	63/10/25	74/10/03	.56	3.0	.0	9	1.13
Red River near Hazel Green	76/01/16	76/08/17	.00	.00	.00	4	.00
	75/07/08	76/08/17	.00	.00	.00	6	.00
Kentucky River Lock 4	75/01/22	75/04/21	.33	1.0	.00	3	.577
	74/03/11	74/09/30	2.6	12.0	.00	7	4.39
	62/11/12	74/09/30	1.06	12.0	.0	17	3.00
Kentucky River Lock 2	76/01/07	76/10/07	.25	1.0	.00	4	.50
	73/04/17	76/10/07	1.06	4.0	.00	16	1.48
Eagle Creek at Glencoe	74/06/06	75/06/06	1.0			1	
	74/03/16	74/12/09	1.2	2.0	.00	6	.753

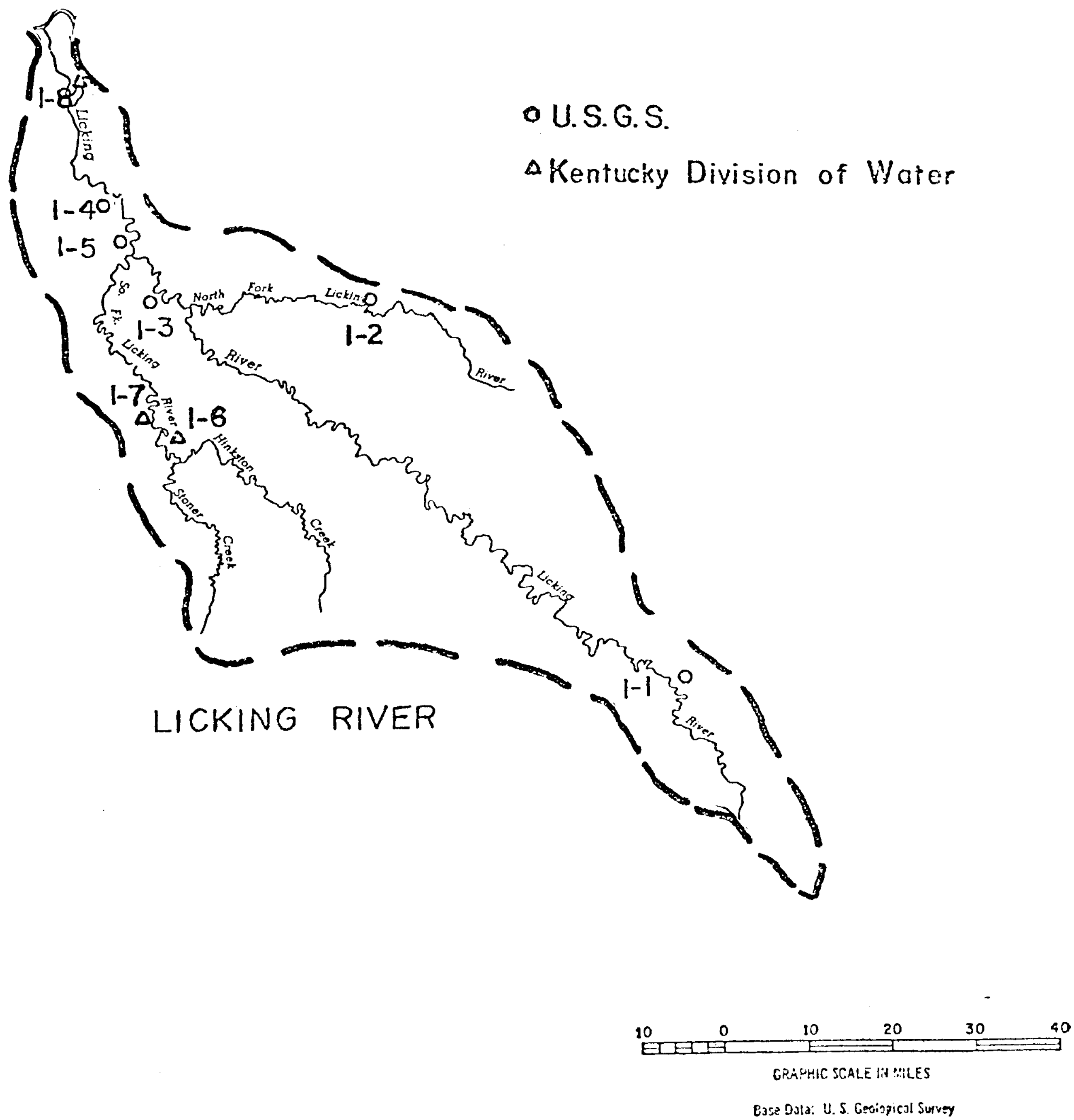
Bacteriological Data

Total Coliform colonies per 100 ml. STORET #31503 Kentucky Standard 1,000/100 ml
Fecal Coliform colonies per 100 ml. STORET #31616

North Fork Kentucky River, Hazard						
Total Coliform	75/02/12	75/11/17	9160	31000	0	11
Fecal Coliform	75/02/12	75/08/13	770	1515	50	7

Table H-9
Bacteriological Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
Kentucky River, Richmond WPI							
Total Coliform	75/01/21	75/12/23	409	1600	0	11	
	74/04/15	75/12/23	665	7000	0	22	
Fecal Coliform	75/09/10		70			1	
	74/09/24	75/09/10	28	70	0	4	
Kentucky River, Lexington WPI							
Total Coliform	75/01/21	75/12/23	476	1600	41	12	
	74/04/15	75/12/23	469	1600	20	22	
Fecal Coliform	75/07/22	75/12/18	16	30	0	3	
Dix River, Danville WPI							
Total Coliform	75/01/30	75/12/17	322	1600	0	12	
	74/04/15	75/12/17	267	1600	0	23	
Fecal Coliform	74/09/24	74/11/26	10	30	0	3	
Kentucky River, Lock #8							
Total Coliform	75/01/21	75/12/23	554	1600	4	11	
	74/04/15	75/12/23	546	2050	4	22	
Fecal Coliform	74/09/24	75/09/10	31	96	0	4	
Kentucky River, Frankfort WPI							
Total Coliform	75/07/31	75/12/17	2788	11000	115	6	
	74/04/30	75/12/17	25778	180000	115	14	
Fecal Coliform	75/08/26	75/12/17	1622	6700	200	5	



LICKING RIVER

THE LICKING RIVER BASIN

This report is in three parts. The first is a general basin description, the second describes the water quality, and the third part summarizes the problems and offers some general solutions.

I. A Description of the Licking River Basin

A. Geography

The Licking River Basin is located entirely within the eastern portion of the Commonwealth of Kentucky. The Licking River rises in southeastern Kentucky and flows northwesterly to its confluence with the Ohio River, opposite Cincinnati, Ohio. The total drainage area of the basin is 3,700 sq. mi. which is approximately 9 per cent of the land area of the state and includes all or portions of 21 counties. The basin is shaped much like an elongated diamond with an axis of about 130 miles and a minor axis of about 60 miles. The main stem is approximately 320 miles long.

The basin extends from Covington and Newport, Kentucky in the north, to below Salyersville in the south and from beyond Flemingsburg and Morehead in the east to Winchester in the west.

B. Topography

The Licking River drainage area is entirely south of the glaciated portion of the Ohio River Basin and physical features of the basin are generally the result of geological strata exposed by differential erosion following the broad uplift of the Paleozoic Era known as the Cincinnati Arch. The Licking River Basin exhibits four distinct physiographic types. The river rises in the Eastern Coal Fields of the Kanawha section of the (1) Appalachian Plateau, which has narrow ridges and crooked steep sided valleys. It flows through the (2) Knobs and the (3) Outer Blue Grass Regions. The South Fork drains a portion of the (4) Inner Blue Grass region of the Interior Low Plateau. The Knobs is an area of conical hills with rather broad valleys. The Outer Blue Grass is rather gently rolling except where the streams have entrenched themselves into deep valleys. The Inner Blue Grass region is gently rolling upland. There are no natural lakes in the basin. The generally flat topography of the Licking River Basin allows little reaeration due to the slope of the streams. Reaeration is the replacement of dissolved oxygen from the atmosphere which is used to stabilize organic matter. The river courses from an elevation of 998 ft. mean sea level (m.s.l.) at its headwaters to an elevation of 420 ft. m.s.l. at the confluence with the Ohio River for some 320 miles. The main stem has an average slope of approximately 1.9 ft./mi. Over the lower half of the river the average slope is 1.3 ft./mi. The slopes of the tributaries average between 1 to 2 ft./mi. for the North and South Forks and into the hundreds of feet per mile in some of the smaller tributaries. A slope in the range of 0 to 2 ft./mi. is considered low, 2 to 6 ft./mi. is moderate and 6 to 10 ft./ mi. is high as it relates to the effect of reaeration.

C. Geology

The major geologic influence on the quality of the water in the Licking River Basin is the occurrence of limestone throughout the basin. Limestone contributes calcium and magnesium through solution from the soil and rocks which imparts hardness to the water. The coal field does not appear to be having a significant effect on water quality at this time.

The groundwater resources are limited by the low yield of the aquifers in the basin, thus restricting the use of groundwater as a major source of water supply.

D. Hydrology

During the late summer and early autumn, portions of the Licking River have flows of less than 5 cubic feet per second (Table I-2). Such low flows severely limit the capacity of a stream to maintain the standard of 5 mg/l of dissolved oxygen. Cave Run Reservoir near Farmers, Kentucky, 174 miles from the mouth, was built to store 47,000 acre feet of water for flood control, water supply recreation and low flow augmentation. Cave Run Reservoir is designed to augment the low flow in the Licking River by 50 cubic feet per second (c.f.s.).

E. Population

The population of the Licking River Basin was 211,000 in 1970. The distribution throughout the basin is fairly uniform except for a major population center in Campbell and Kenton Counties, composing a part of the SMSA of Cincinnati, Ohio. Although Campbell and Kenton Counties do not discharge treated sewage into the Licking River, combined sewer overflow and street run-off do affect water quality in the lower Licking River. The total urban population of the basin is 106,000 or 50 per cent of the whole basin. The other 50 per cent is in rural areas.

TABLE I-2

SURFACE WATER RECORDS FOR THE LICKING RIVER BASIN

STATION	PERIOD OF RECORD	DRAINAGE AREA	AVERAGE FLOW	MAXIMUM FLOW	MINIMUM FLOW	7-day/10-yr. LOW FLOW
Licking River at Farmers **	38 yr.	827 sq.mi.	1,067 cfs, 1.3cfs*/sq.mi.	24,000 cfs, 29cfs/sq.mi.	0.7 cfs, 0.0cfs/sq.mi.	54.4 cfs
	wtr/yr 1976		851 cfs, 1.0cfs/sq.mi.	3,380 cfs, 5cfs/sq.mi.	8.5 cfs, 0.0cfs/sq.mi.	
South Fork Licking River at Cynthiana	38 yr.	621 sq.mi.	763 cfs, 1.2cfs/sq.mi.	35,300 cfs, 57cfs/sq.mi.	0.3 cfs, 0.0cfs/sq.mi.	0.9 cfs
	wtr/yr 1976		732 cfs, 1.2cfs/sq.mi.	19,800 cfs, 32cfs/sq.mi.	3.7 cfs, 0.0cfs/sq.mi.	
Licking River at Catawba **	50 yr.	3,300 sq.mi.	4,144 cfs, 1.3cfs/sq.mi.	95,000 cfs, 29cfs/sq.mi.	2.5 cfs, 0.0cfs/sq.mi.	62 cfs
	wtr/yr 1976		3,560 cfs, 1.1cfs/sq.mi.	44,200 cfs, 13cfs/sq.mi.	80 cfs, 0.0cfs/sq.mi.	

* Cubic feet per second

** Flow regulated since December, 1973 by Cave Run Lake.

NOTE: Data is taken from "Surface Water Records in Kentucky" by the United States Geological Survey. The 7-day/10-yr. low flow was taken from the waste load allocation produced as a component of the 303e River Basin Continuing Planning Process.

II. Basin Water Quality

The water quality of the Licking River Basin has been determined by using both a computer model and data collected at three monitoring stations. These sources give an overall picture of the basin which shows problems caused by sewage treatment plant effluent and erosion.

A. Description of Sampling Stations

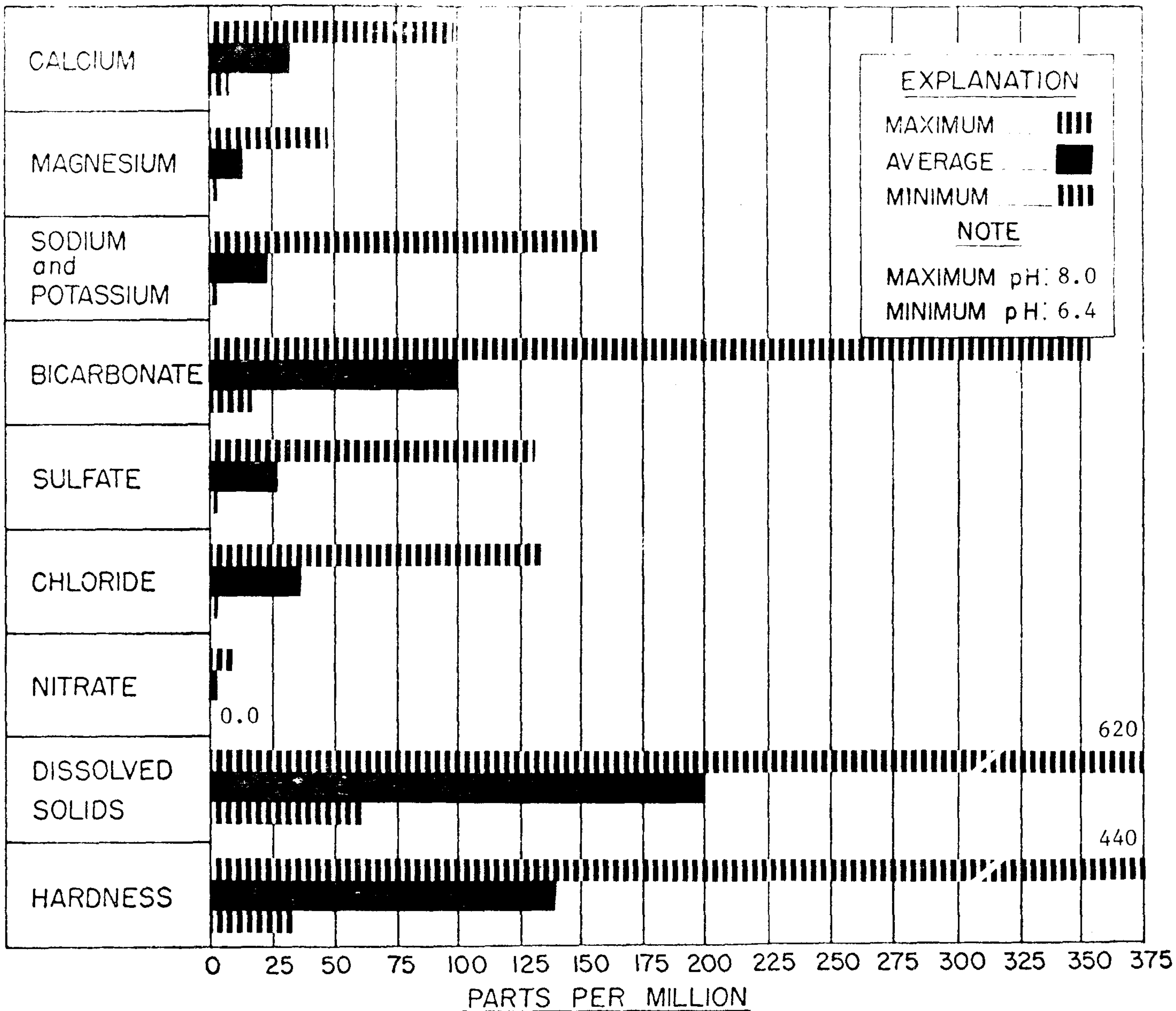
The Salyersville monitoring station, the farthest upstream of the three stations, is on the Licking River 1.2 miles west of Salyersville and 266 miles from the mouth. The drainage area at this point is 140 sq. mi.

The second station, at McKinneysburg, on the Licking River is 64 miles from the mouth and has a drainage area of 2,300 sq. mi.

The last station is at the Kenton County water intake on the Licking River approximately 2 miles from the mouth at the Ohio River. The drainage area at this station is approximately 3,700 sq. mi.

B. General Chemical Water Quality

The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The chemical characteristics of a stream when viewed over a long period of time is primarily from surface water. The type of rock formation and soils which the surface water contacts causes this predominate chemical characteristic. The contribution of groundwater, which is generally higher in dissolved solids than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky is of moderate hardness caused by calcium and magnesium salts. The influence of mining activities are clearly indicated when the sulfate content increases to a higher level than the bicarbonate content, and the pH is on the acid side, below pH 5.5.



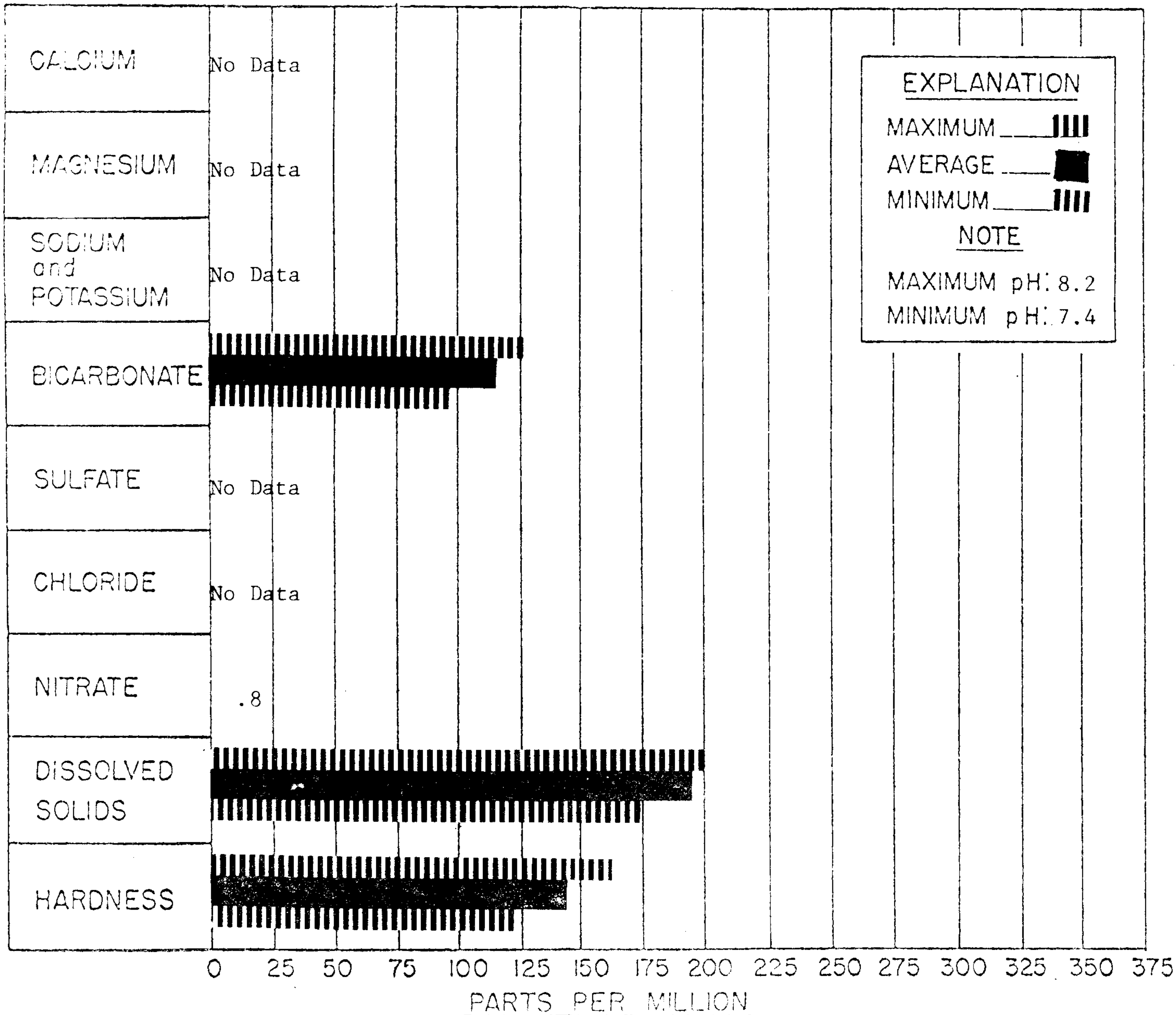
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE I-1

Licking River

Salyersville

5-65 to 11-74

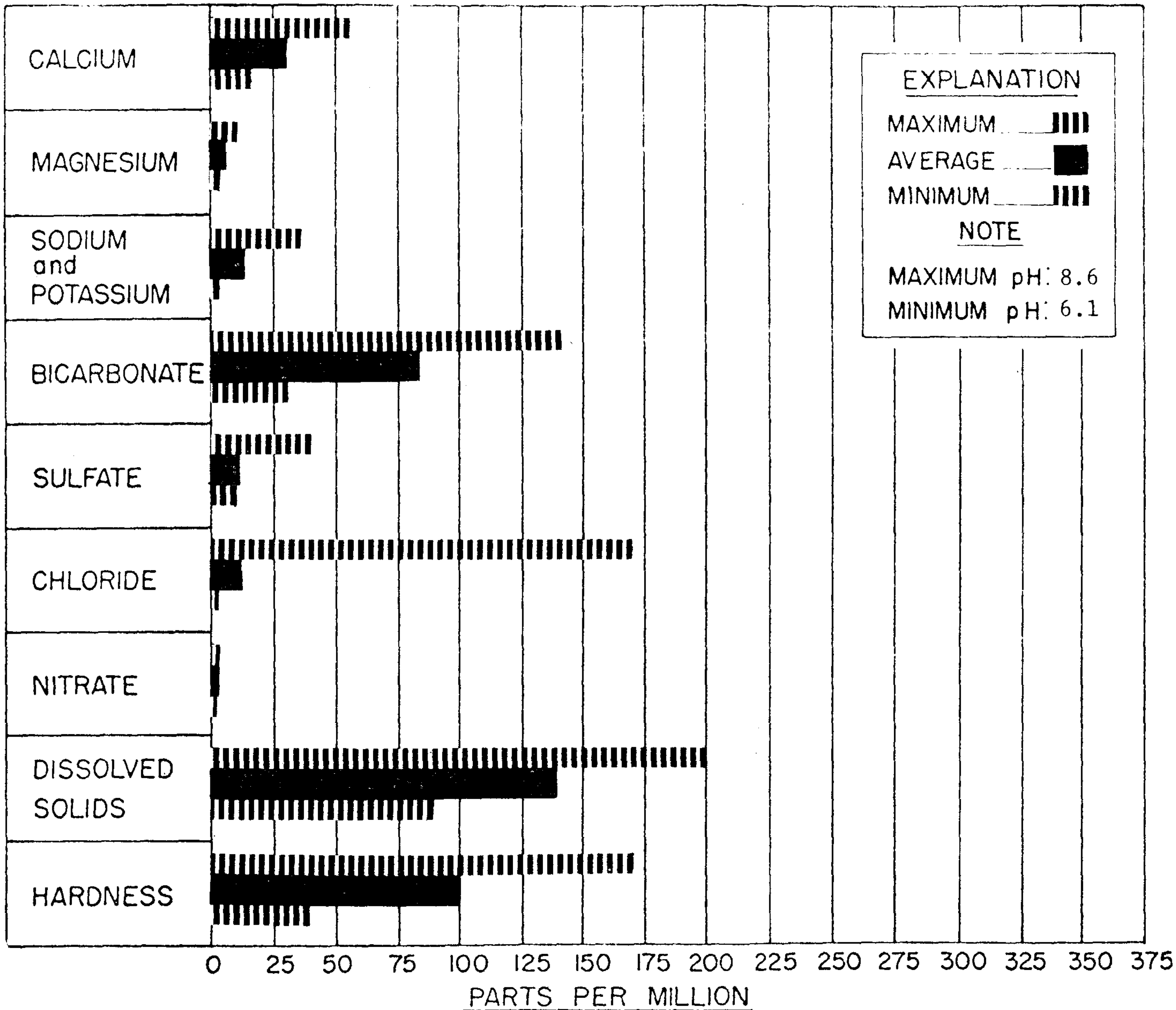


MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE I-2

North Fork Licking River

9-70 to 8-72



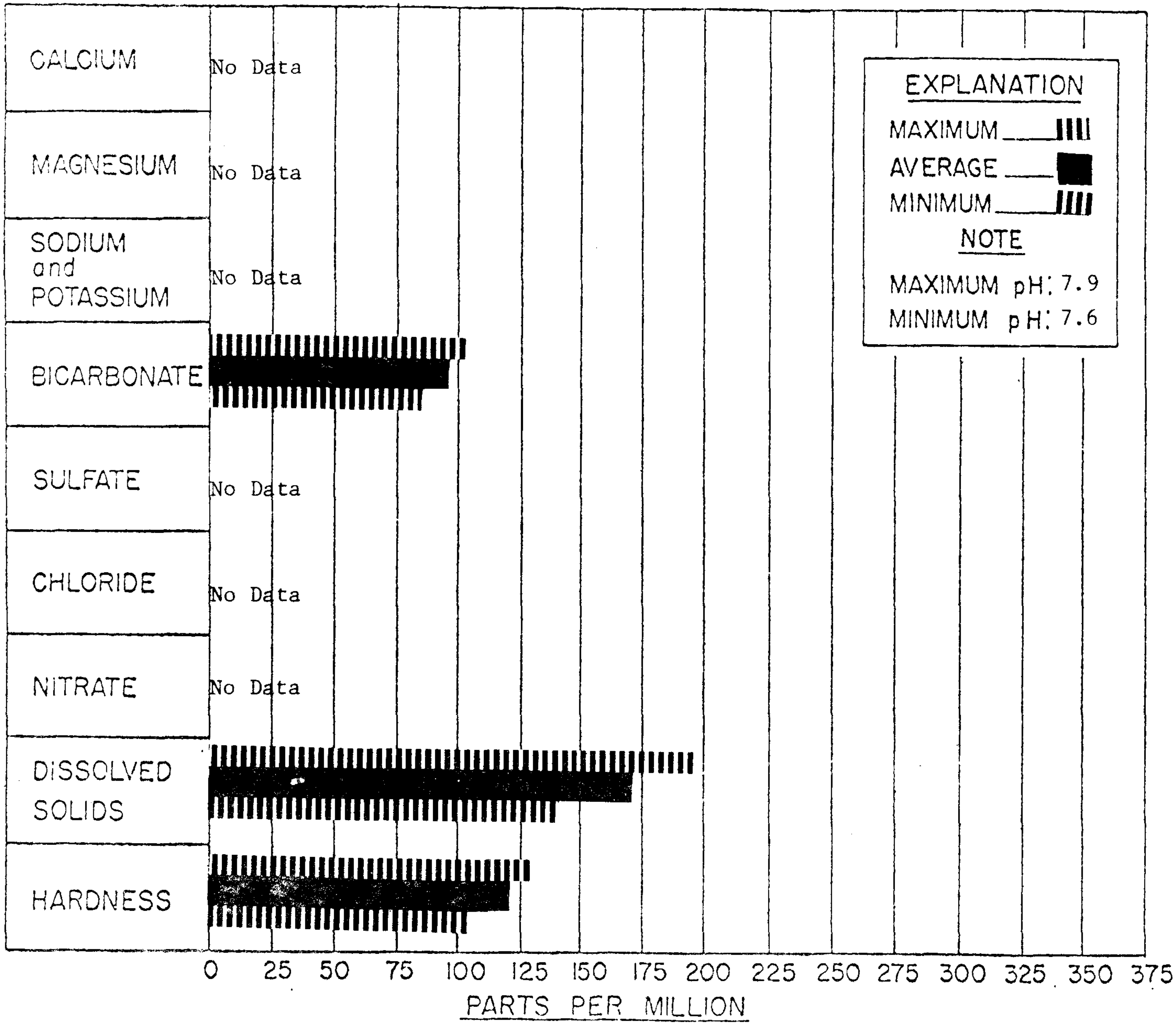
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE I-3

Licking River

McKinneysburg

10-59 to 10-73



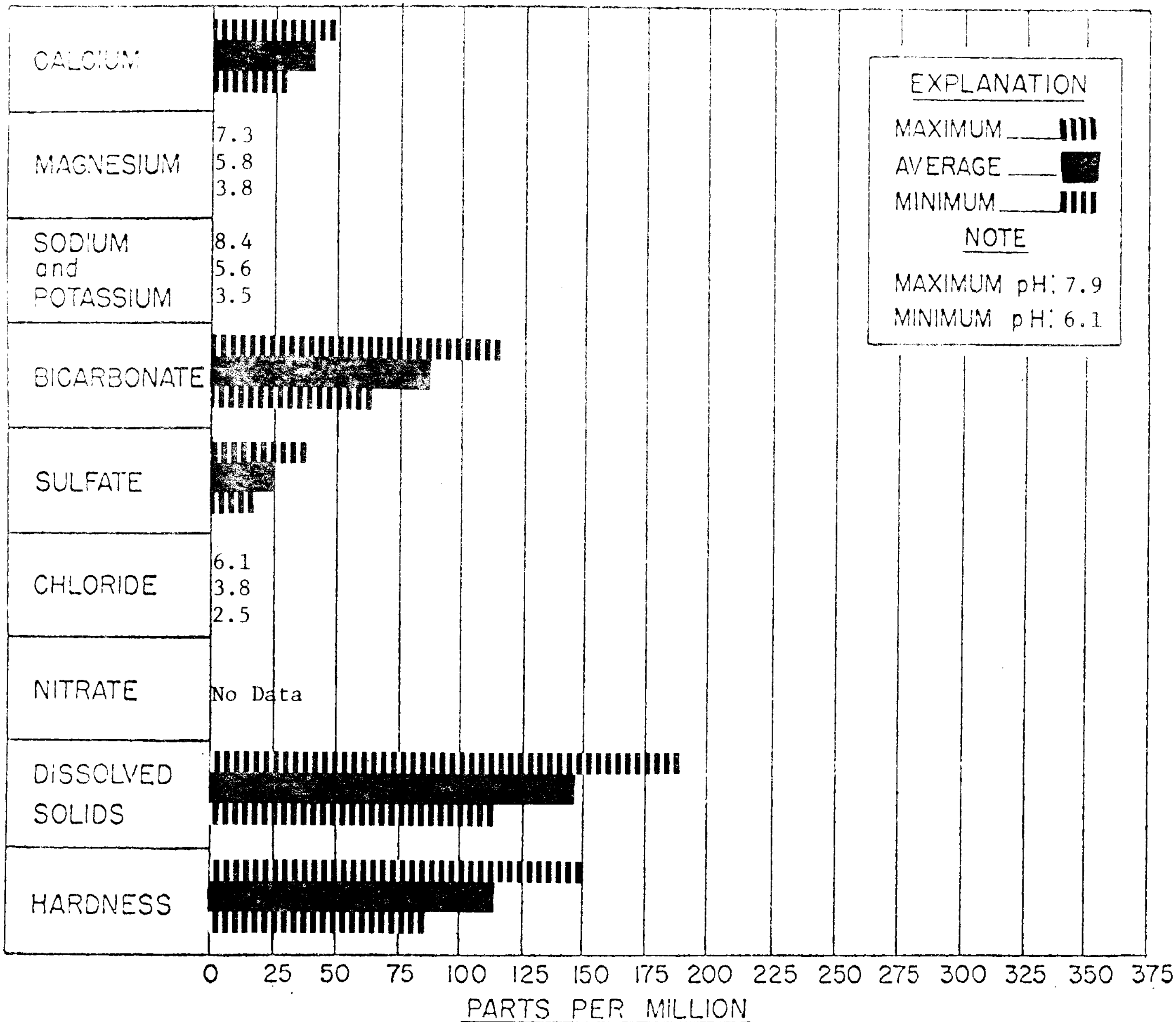
MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE I-4

Licking River

Catawba

1962 to 1974



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents

FIGURE I-5

Licking River

Butler

10-74 to 12-75

Oil field operations, when brine is encountered, are reflected by changes in sodium and chloride contents of the water. For Kentucky water, the influence is pronounced when either chloride or sodium exceeds 20-25 parts per million as an average value.

Two sampling stations which were used to depict the general chemical water quality for the Licking River basin reflect two different situations on the river.

Salyersville was selected to determine the effect of coal mining on water quality. This station is near the headwaters and above Cave Run Reservoir, and shows a wide variation in chemical quality partly due to the relatively small drainage area. That area is totally within the eastern coal field and fluctuations at the Salyersville station indicate the effects of coal mining and oil field operations on water quality. The effect of coal mining and oil field productions is illustrated principally in Figure I-1. The extreme variation in all parameters in comparing the average to the maximum indicates the influence of sporadic discharges which impacts water quality primarily at low flow periods. The production of coal in the Licking River Basin is low as compared to the coal reserves. Oil field production is primarily limited to recharge well production which is limited. Both of these developments reflect the primary influence of water quality, particularly at times of low flow, since the average values are much as would be expected without oil or coal production. Figure I-4 indicates that the water is typical of Kentucky stream water when looking at the average values.

McKinneysburg, another station, was selected to indicate general chemical water quality of the majority of the drainage basin (62%) and the effects of Cave Run Reservoir as compared with the Salyersville station.

The water is classified as soft, moderately hard, hard, and very hard due to the concentration of certain ions, primarily calcium and magnesium. The range of hardness is 121 mg/l + 180 mg/l with an average of 136 which is hard water.

The impact on water quality from Cave Run Reservoir at McKinneysburg is clearly illustrated by comparing the graphs of McKinneysburg and Salyersville. All parameters decrease at McKinneysburg which demonstrates the effectiveness of water reservoir impoundments for quality control of the general chemical quality of water and the ability of a reservoir to iron out or stabilize imparted chemical quality from the exploration of mineral resources such as coal and iron field developments.

C. Trace Chemical Water Quality

Trace elements (under 5 mg/l) are separated from the general chemical background of this report because of their influence on human health. Generally, these materials are "heavy" metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the Kentucky Federal Water Quality Standards.

The trace chemical results were from samplings at the Kenton County water district and in the Licking River Basin the water quality falls within the Kentucky-Federal Water Quality Standards.

D. Waste Load Effects on Water Quality

Biochemically degradable wastes impose a load on the dissolved oxygen resources of a stream. Such waste loads are considered to have an adverse effect on water quality when they cause the dissolved oxygen concentration of the water to drop below the Kentucky water quality standard of 5.0 mg/l. Approximately 1,000 miles of stream length were studied using a model to determine waste load allocations. The model was developed in the Kentucky Continuing Planning process for River Basin Management Planning. Using this model it was determined that approximately 384 miles are affected by treated wastewater. Of the 384 miles 46 miles are affected by industry, 89 miles by municipal sewage treatment plants and 249 miles are affected by other sources such as schools, trailer parks, motels, etc.

E. Non-Point Source Effects

Major non-point source pollution problems in the Licking River basin include sediment from agricultural erosion, field gullies, streambank erosion, roadbank erosion, and erosion from soil disturbances during development of areas for commercial, residential, and industrial purposes. The following estimates were obtained from Soil Conservation Survey of U. S. Department of Agriculture.

Erosion from about 78 sq. mi. of cropland contributes an estimated 57% of the total annual sedimentation entering the stream system.

It is estimated that over 24% of the sediment entering the Licking River annually is a result of erosion from construction sites. The source is concentrated in the lower section of the basin.

Approximately 5.5 sq. mi. of field gullies have a potential for producing 10% of the annual sedimentation.

Streambank erosion is severe on about 400 miles in the basin, with a potential for producing over 7% of the sediment annually.

Approximately 170 miles of critical roadbank erosion have the potential for producing 2% of the sediment annually.

F. Water Uses

The major use of water in the Licking River Basin is industrial. An estimated 18 million gallons per day (m.g.d.) are used by industries while 9 m.g.d. are used for public consumption. Kenton County Water District #1 withdraws approximately 50% of the total public withdrawal and Interlake Steel Corporation withdraws approximately 80% of the industrial total. A complete breakdown can be found in Table I-6.

The Licking River is a well known Kentucky fishing stream. Throughout much of the basin high quality fish can be taken including "muskie" and bass. Cave Run Reservoir offers even more opportunity for recreational activities, and the area is now being developed to include more boating and swimming facilities.

The primary use of water in the basin for agriculture is livestock watering. The water quality doesn't limit the use for other agricultural practices but rather the usually abundant rainfall provides a more than adequate amount of water without supplementation from streams.

III Summary

The water quality as indicated by the Salyersville, McKinneysburg and Kenton County gauging stations appears to be good. Salyersville is particularly good even though it is in a mining area and McKinneysburg is even better due to the larger drainage area and the buffering action of Cave Run Reservoir.

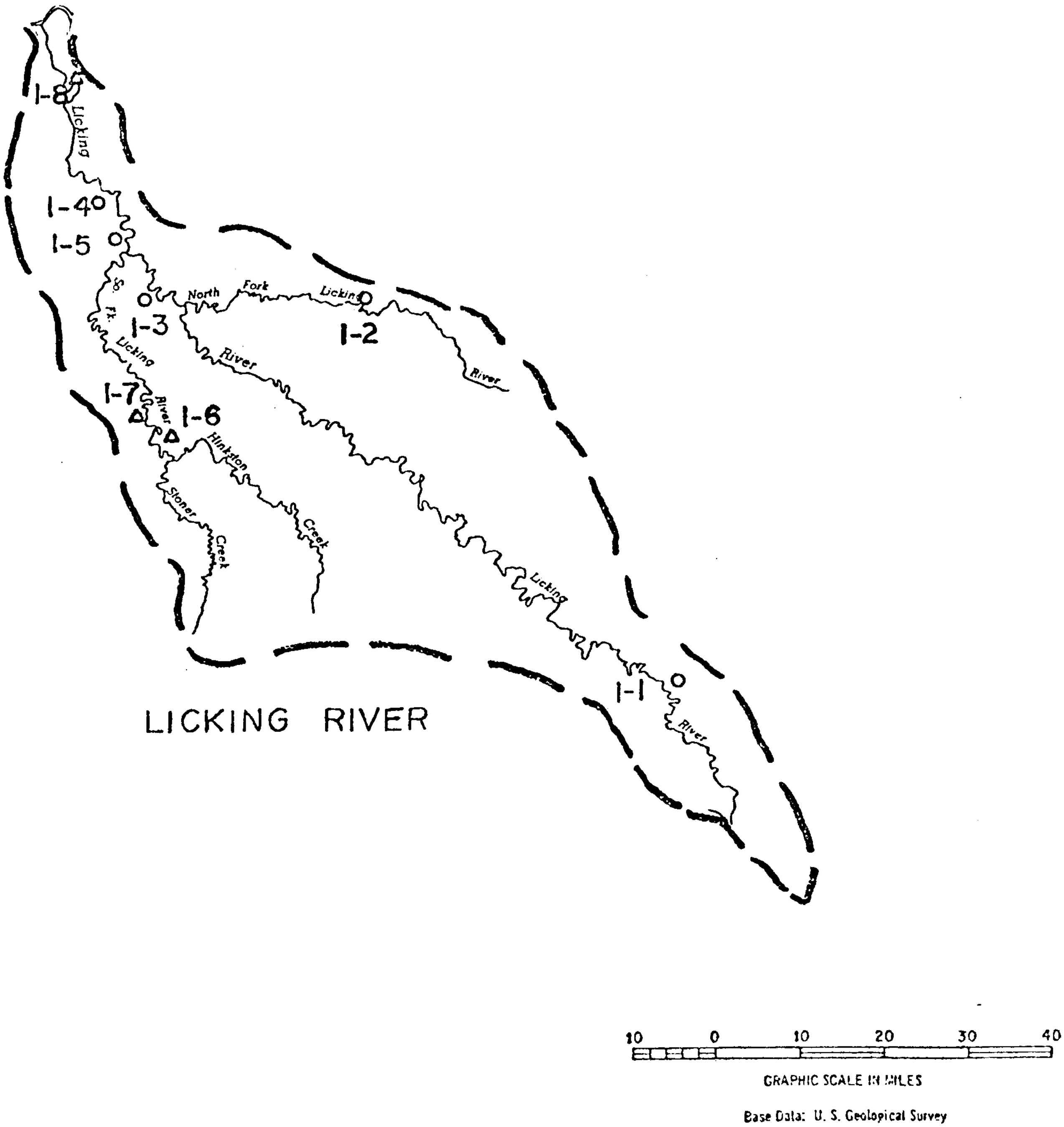
The two problem areas that presently need the most attention in the Licking River Basin are erosion with subsequent siltation, and possible stream degradation due to sewage treatment plant effluent.

Both problems lend themselves to easy statements for solutions; such as better land use management for control of erosion and upgrading sewage treatment facilities for both the private and public sectors.

The majority of the siltation comes from cultivated fields. Much of the Licking River Basin is in an agricultural area and the implementing of farming practices to prevent soil erosion is needed. The real possibility of a threefold increase in coal mining in Kentucky also raises the prospect of increased siltation and acid mine drainage. The coal fields in the Licking River Basin are relatively undeveloped and the trend to increased coal mining can pose a serious threat to the basin's water quality. Present and possible future federal and state legislation controlling mining practices will be needed if the integrity of water quality is to be maintained.

The sewage treatment plant effluent problem is very complex. Upgrading of existing facilities is underway in both the construction and planning phases. Numerous small "package" treatment plants still dot the countryside. The effluent from these plants is often of inadequate quality to protect the receiving stream. This large number and relatively small size make operation and enforcement difficult. Either an improvement in the design of "package" treatment plants or running sewers from these outlying areas to central sewage treatment plants is needed to protect the small tributaries.

Neither of the above mentioned problems are peculiar to the Licking River Basin in Kentucky. Their solution will most likely be a part of the statewide implementation of the 303e River Basin Planning Process and other related programs.


I-8
Licking
I-4
I-5
I-3
North Fork Licking
I-2
River
S. Fk. Licking River
River
I-7
I-6
Hinkston Creek
Stoner Creek
Licking
I-1
River
LICKING RIVER
10 0 10 20 30 40
GRAPHIC SCALE IN MILES
Base Data: U. S. Geological Survey

STATION KEY

I-1 LICKING RIVER AT SALYERSVILLE
I-2 NORTH FORK LICKING RIVER
I-3 LICKING RIVER AT McKINNEYSBURG
I-4 LICKING RIVER AT BUTLER
I-5 LICKING RIVER AT CATAWBA
I-6 LICKING RIVER AT PARIS
I-7 LICKING RIVER AT CYTHIANA
I-8 LICKING RIVER AT KENTON Co. WATER PLANT INTAKE

Table I-1

Drainage Areas in the Licking River Basin

* a. Total Area in Square Miles 3707

b. Sub-basins over 200 square miles

Licking River Basin	3707 sq. mi.
1. North Fork Licking	308 sq. mi.
2. Slate Creek	230 sq. mi.
3. South Fork Licking	927 sq. mi.
a. Stoner Creek	284 sq. mi.
b. Hinkston Creek	260 sq. mi.

c. Area of Basin in each County**

			Total Sq. Mi.	Sq. Mi.*** in basin
1.	Bath	100 %	287	287
2.	Boone	1.9%	249	7
3.	Bourbon	100 %	300	300
4.	Bracken	44 %	204	90
5.	Campbell	44 %	149	65
6.	Clark	37 %	259	95
7.	Elliott	4 %	240	9
8.	Fleming	100 %	350	350
9.	Grant	36 %	249	91
10.	Harrison	100 %	308	308
11.	Kenton	86 %	165	143
12.	Lewis	8 %	486	39
13.	Magoffin	96 %	303	290
14.	Mason	62 %	238	147
15.	Menifee	62 %	210	131
16.	Montgomery	88 %	204	180
17.	Morgan	90 %	369	332
18.	Nicholas	100 %	204	204
19.	Pendleton	91 %	279	255
20.	Robertson	100 %	101	101
21.	Rowan	94 %	290	273

* Drainage Areas in Kentucky, Frankfort, Kentucky, December 20, 1974

** Area - U. S. Census - Source of measurement - Approximately ± 10%

*** Percent in Basin - Federal Water Pollution Control Administration - Ohio River Basin Framework Comprehensive Study

Table I-3

City Population and Facility Grant Status
in the Licking River Basin in Kentucky

County	City	Population	Project Type	Comments
Bath	Owingsville	1,381	1	Active
	Bath Co. W. D.	441	1	Active
Bourbon	Paris	7,823	1	Active
	Millersburg	788	1	Active
			2	Pending
	North Middletown	433	None	Sewers/STP
Campbell	Alexandria	3,844	None	Sewers/STP
	Sanitation District #2		None	Sewers/STP
Clark	Winchester	13,402	1 & 2	Active
Fleming	Flemingsburg	2,483	1	Active
Grant	Crittenden	359	None	No Sewers
	Corinth	236	None	No Sewers
Harrison	Cynthiana	6,356	3	Active
	Berry	266	None	No Sewers
Kenton	Elsmere	5,161	None	Sewers/STP
	Independence	1,784	None	No Sewers
	Park Hills	3,999	None	Sewers/STP
Magoffin	Salyersville	1,196	1	Active
Menifee	Frenchburg	467	None	Sewers/STP
Montgomery	Mt. Sterling	5,083	1 & 2	Active
	(Sanitation District #1)		3	Active
	Sanitation District #2	700	1	Active
Morgan	West Liberty	1,387	None	Sewers/STP
Nicholas	Carlisle	1,579	1	Active
Pendleton	Falmouth	2,593	1	Active
	Butler	558	None	Sewers/STP

Table I-3
Continued

County	City	Population	Project Type	Comments
Robertson	Mt. Olivet	442	None	No Sewers
Rowan	Morehead	7,191	1 2	Active Active

NOTE: Project type is related to the grant process step applied for or active for each municipality. Step 1 is the preliminary studies (201 Facilities Plan) required before design of the facilities. Step 2 is the design phase of the project, and Step 3 is the construction of facilities for the collection and treatment of wastewaters.

The comments relate to the status of the grant. Active indicates the project is funded and underway. Pending indicates that application for a grant has been made and is pending approval. No sewers indicates that the municipality does not presently have a comprehensive sewer system. Sewers/STP indicates the municipality is now served by sewers and treatment facilities.

The source of this information was the 1970 U. S. Census and the FY 77 construction grants list for Kentucky.

TABLE I-4

Population in the Licking River Basin by County

COUNTY	TOTAL POP. 1970	POP. IN BASIN
Bath	9,114	9,114
Boone	21,940	150
Bourbon	18,178	18,178
Bracken	7,422	2,400
Campbell	86,803	9,500
Clark	21,075	16,000
Elliott	6,330	200
Fleming	10,890	10,890
Grant	9,489	5,000
Harrison	13,704	13,704
Kenton	120,700	49,000
Lewis	13,115	900
Magoffin	11,156	10,000
Mason	18,454	7,000
Menifee	4,276	2,800
Montgomery	13,461	13,000
Morgan	11,056	9,100
Nicholas	6,677	6,677
Pendleton	9,949	9,400
Robertson	2,163	2,163
Rowan	17,010	16,000
		211,176

Table I-5

Organic Loads Affecting Streams in the Licking River Basin

Length of streams to which treated organic loads are discharged		1,000
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow		384
Stream length for which dissolved oxygen is predicted to be below 5 mg/l during periods of low flow due to	Municipal Discharges	89
	Industrial Discharges	46
	Other Discharges	249

NOTE: This information is from the waste load allocation for Kentucky and is an output from the 303e river basin planning effort. The values indicated the stream miles in which the dissolved oxygen is predicted to be less than 5 mg/l when the stream flow is less than the once in ten year, seven day, low flow.

TABLE I-6

WATER WITHDRAWAL IN THE LICKING RIVER BASIN

COUNTY	CREEK	SW *	GW **	PUBLIC	INDUSTRIAL
BATH					
Municipal Water & Sewer Service	Slate Creek	x		.150 MGD ***	
Sharpsburg Water District	Reservoir	x		.032 MGD	.003 MGD
BOONE					
Municipal Water Works Walton	Two Lakes	x		.098 MGD	
BOURBON					
Paris Municipal Water Works	Stoner Creek		x	.575 MGD	.530 MGD
Millersburg Municipal Water Works	Hinkston Creek	x		.105 MGD	.005 MGD
N. Middletown Municipal Water Works	Stoner Creek	x		.046 MGD	
CAMPBELL					
Interlake Steel Corporation	Licking River	x			14.9 MGD
FLEMING					
Flemingsburg Municipal Water Works	2 reservoirs	x		.107 MGD	.088 MGD
Western Fleming Water District, Ewing	Licking River	x		.206 MGD	.004 MGD
GRANT					
Williamstown Municipal Water Works	Lake Branch Res.	x		.173 MGD	.051 MGD
Corinth, Wm. O. Ratcliff	Reservoir	x		.013	
HARRISON					
Cynthiana Municipal Water Works	S. Fork of Licking River	x		.773	.515
Cynthiana, Joseph E. Seagram and Sons	S. Fk. Licking River & Well	x	x		.010 GW 1.250 SW

Continued - I-6

COUNTY	CREEK	SW	GW	PUBLIC	INDUSTRIAL
KENTON Kenton Co. Water Dist. #1 S. Fort Mitchell	Licking River	x		4.663	.047
MONTGOMERY Mt. Sterling Municipal Water Works	Slate Creek Res.	x		.235	.941
MORGAN West Liberty Municipal Water Works	Licking River	x		.175	
NICHOLAS Carlisle Municipal Water Works	Two Lakes	x		.230	.012
PENDLETON Falmouth Municipal Water Works	Licking River	x		.310	.020
Mago Construction Co. Inc. Bardstown	Licking River	x			.001
Butler Municipal Water Works	Licking River	x		.086	
ROBERTSON Mt. Olivet Municipal Water Works	Licking River	x		.030	
ROWAN Morehead State University	Evans Br. Res. S. Fk. Triplett Cr.	x		.548	.029
Morehead Utility Plant Board	Licking River	x		.412	.008
Tennessee Gas Pipeline Co. Morehead	N. F. Triplett Creek	x			.010
Morehead	Impoundment on Schoolhouse Br.	x			.001
			TOTAL	8.967	18.413

SW - Surface Water
GW - Ground Water
MGD - Million Gallons per Day

Table I-7

Water Quality Data in the Licking River Basin

Station	Beg. Date	End Date	Mean	Max.	Min.	OBS.	S
STORET #00400	pH Specific Units Kentucky Standard 1-LT pH-9						
Licking River Salyersville U.S.G.S. #03248500	70/07/29	74/10/02	6.9	7.3	6.4	37	.214
	65/05/19	74/10/02	6.9	7.3	6.4	38	.212
N. Fork Licking River LE U.S.G.S. #03251000	70/09/23	72/08/15	7.8	8.2	7.4	3	.400
Licking River McKinneysburg U.S.G.S. #03251500	70/01/13	73/09/25	7.7	8.4	6.9	94	.342
	65/01/13	73/09/25	7.6	8.6	6.6	212	.371
	59/11/03	73/09/25	7.6	8.4	6.1	268	.396
Licking River Butler U.S.G.S. #03254000	76/01/13	76/11/17	6.8	8.1	6.3	11	.492
	74/10/17	76/11/17	7.0	8.1	6.1	25	.525
Licking River Catawba U.S.G.S. #03253500	70/09/23	72/08/15	7.9	7.9	7.9	3	.008
	62/09/24	72/08/15	7.8	7.9	7.6	4	.150
STORET #00095	Conductivity Micro mhos, Ky. Std. 800 micro mhos						
Licking River Saylersville	76/01/17	76/09/27	222.4	456.9	120.0	7	125.5
	70/07/29	74/11/19	279.7	1170	102.0	44	201.2
	65/05/19	76/09/27	260.9	1170.0	100.0	61	180.6
N. Fork Licking River LE	76/06/03	76/06/03	190.0	190.0	190.0	1	– –
	70/09/23	76/06/03	230.2	315.0	100.0	5	87.3
Licking River McKinneysburg	70/01/03	73/09/25	232.3	801.0	103.0	94	87.1
	65/01/13	73/09/25	237.8	801.0	103.0	223	78.4
	59/10/07	73/09/25	238.4	801.0	102.0	368	76.6
Licking River Butler	76/01/08	76/12/03	244.6	330.0	165.0	12	64.2
	74/10/17	76/12/03	245.4	338.0	165.0	26	55.8
Licking River Catawba	70/09/23	74/08/23	235.3	264.0	212.0	6	22.8
	62/09/24	74/08/23	242.6	286.0	212.0	7	28.3

Table I-7
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	OBS.	S
STORET #70300	Dissolved Solids mg/l, Kentucky Standard 500 mg/l						
Licking River Salyersville	76/01/17	76/09/27	129.9	245.0	82.0	7	59.5
	70/07/29	76/09/27	153.5	722.0	50.0	60	108.6
N. Fork Licking River LE	70/09/23	72/08/15	190.0	200.0	174.0	3	14.0
Licking River McKinneysburg	70/01/03	75/10/09	142.7	490.0	64.0	94	53.6
	65/01/13	73/09/25	148.2	490.0	62.0	223	48.1
	53/10/26	73/09/25	143.7	490.0	62.0	423	42.6
Licking River Butler	76/01/08	76/11/17	157.0	232.0	96.0	11	41.7
	74/10/17	76/11/17	150.4	232.0	96.0	26	31.7
Licking River Catawba	70/09/23	72/08/15	177.7	194.0	138.0	3	30.3
STORET #00410	Alkalinity mg/l, No Standard						
Licking River Salyersville	76/01/17	76/09/27	26.1	43.0	16.0	7	11.0
	70/07/29	76/09/27	36.4	86.0	13.0	60	19.7
N. Fork Licking River LE	70/09/23	72/08/15	116.3	126.0	98.0	3	15.9
Licking River McKinneysburg	70/01/03	73/09/25	79.7	141.0	31.0	94	27.5
	65/10/07	73/09/25	82.0	141.0	31.0	171	26.3
Licking River Butler	76/01/08	76/11/17	89.4	127.0	57.0	11	25.4
	74/10/17	74/11/17	89.6	127.0	57.0	26	20.2
Licking River Catawba	62/09/24	72/08/15	95.8	103.0	82.0	4	9.9
STORET # 00900	Hardness mg/l, 0-6- Soft, 61-120 MOD, Hard, 121-180 Hard, 180 + Very Hard						
Licking River Salyersville	76/01/17	76/09/27	64.7	100	40	7	23.1
	70/07/29	74/11/19	72.0	200	32	44	34.9
	65/05/19	76/09/27	70.9	200	32	61	33.0
N. Fork Licking River LE	70/09/23	72/08/15	140.0	160.0	120.0	3	20.0

Table I-7
Continued

Station	Beg. Date	End Date	Mean	Max.	Min	OBS.	S
Licking River McKinneysburg	70/01/03	73/09/25	103.1	170.0	42.0	94	32.1
	65/01/13	73/09/25	106.3	171.0	42.0	213	31.8
	59/10/07	73/09/25	102.9	171.0	39.0	341	29.0
Licking River Butler	76/01/08	76/11/17	123.6	170.0	68.0	10	33.3
	74/10/17	76/11/17	119.5	170.0	68.0	25	26.2
Licking River Catawba	62/09/24	72/08/15	120.0	130.0	104.0	4	12.7
STORET #00915	Calcium mg/1, No Standard						
Licking River Salyersville	76/01/17	76/09/27	15.6	28.0	9.2	7	6.8
	70/07/29	76/09/27	18.3	56.0	7.4	60	9.9
Licking River McKinneysburg	70/10/17	72/10/31	38.0	51.0	30.0	3	11.4
	68/11/01	72/10/31	38.0	51.0	30.0	5	8.2
	59/11/03	72/10/31	31.4	55.0	16.0	23	9.3
Licking River Butler	76/01/08	76/11/17	38.2	51.0	20.0	10	10.3
	74/10/17	76/11/17	37.4	51.0	20.0	25	8.0
STORET #00925	Magnesium mg/1, No Standard						
Licking River Salyersville	76/01/17	76/09/27	6.4	8.8	4.2	7	1.9
	70/07/29	76/09/27	6.1	14.0	1.9	60	2.4
Licking River McKinneysburg	70/10/17	72/10/31	7.0	7.6	6.1	3	.794
	68/11/01	72/10/31	7.6	9.5	6.1	5	1.2
	59/11/03	72/10/31	5.7	9.5	2.7	23	1.6
Licking River Butler	76/01/08	76/11/17	6.7	11.0	4.5	10	2.1
	74/10/17	76/11/17	6.3	11.0	3.8	25	1.7
STORET #00618	Nitrate mg/1 Proposed E.P.A. Std. 10 mg/1						
Licking River Salyersville	76/01/17	76/09/27	0.34	0.47	0.22	7	0.10
	71/10/14	76/09/27	0.30	0.63	0.06	47	0.13
N. Fork Licking River LE	72/08/15	72/08/15	0.8			1	

Table I-7
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	OBS	S
Licking River	71/10/05	73/09/25	0.72	1.5	0.01	49	.30
McKinneysburg	71/10/05	73/09/25	0.72	1.5	0.01	49	.30
Licking River	72/08/15	72/08/15	1.3			1	
Catawba							
STORET #01000	Arsenic ug/1, Kentucky Std. 50 ug/1						
Licking River	75/01/02	75/03/24	0.0	0.0	0.0	3	0.0
Salyersville	74/04/01	74/11/19	2.5	8.0	0.0	4	3.7
	74/04/01	75/03/24	1.4	8.0	0.0	7	2.9
N. Fork Licking	76/06/03	76/11/17	1.0	1.0	1.0	2	0.0
River LE	75/07/10	76/11/17	0.83	1.0	0.0	6	0.4
Licking River	65/01/02	65/09/30	0.0	0.0	0.0	9	0.0
McKinneysburg	63/10/29	65/09/30	0.0	0.0	0.0	23	0.0
Licking River	76/01/08	76/07/09	0.3	1.0	0.0	3	0.6
Butler	74/10/17	76/07/09	0.1	1.0	0.0	8	0.3
Licking River	75/06/25	75/06/25	1.0			1	
Catawba	74/03/14	74/12/10	1.2	3.0	0.0	6	1.3
STORET #00950	Fluoride micrograms/liter, Kentucky Std. 1.0 mg/1						
Licking River	76/01/17	76/09/27	0.20	0.3	0.1	7	0.08
Salyersville	70/07/29	76/09/27	0.16	0.6	0.0	59	0.11
N. Fork Licking	70/09/23	72/08/15	0.2	0.3	0.1	3	0.1
River LE							
Licking River	70/09/23	72/10/31	0.17	0.3	0.1	7	.08
McKinneysburg	68/11/01	72/10/31	0.17	0.3	0.1	9	.07
	59/11/03	72/10/31	0.18	0.4	0.1	22	.09
Licking River	76/01/08	76/11/17	0.20	0.3	0.1	10	0.07
Butler	74/10/17	76/11/17	0.20	0.4	0.0	25	0.09
Licking River	70/09/23	72/08/15	0.23	0.3	0.1	3	.12
Catawba	62/09/24	72/08/15	0.2	0.3	0.1	4	0.1
STORET #01025	Cadmium micrograms/liter, Kentucky Std. 100 ug/1						
Licking River	75/01/02	75/03/24	0.33	1.0	0.0	3	.58
Salyersville	74/04/01	74/11/19	5.8	18.0	1.0	4	8.2

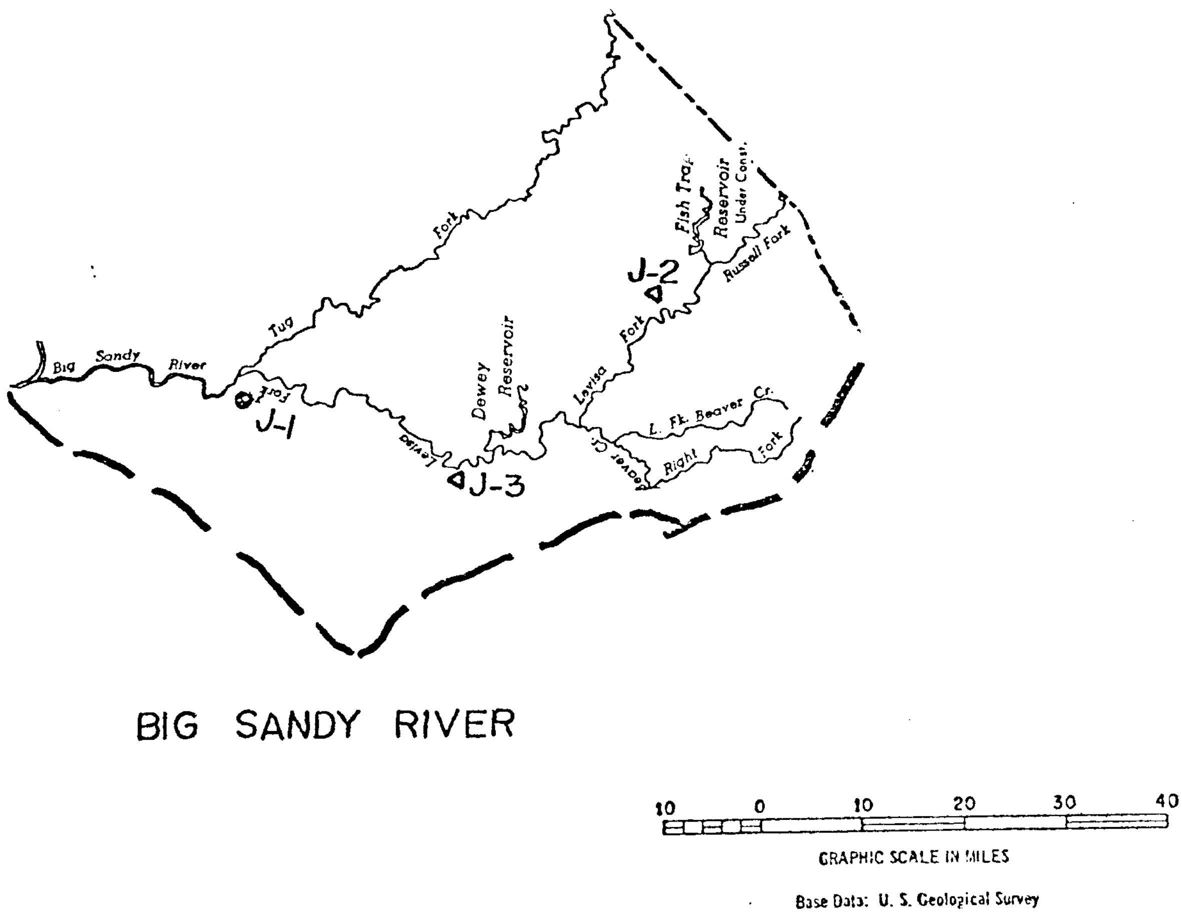
Table I-7
Continued

Station	Beg. Date	End Date	Mean	Max.	Min.	OBS	S
N. Fork Licking	76/06/03	76/11/17	3.0	4.0	2.0	2	1.4
River LE	75/07/10	76/11/17	1.8	4.0	1.0	6	1.2
Licking River	65/01/02	65/09/30	0.0	0.0	0.0	9	0.0
McKinneysburg	63/10/29	65/09/30	0.0	0.0	0.0	23	0.0
Licking River	76/01/08	76/07/09	0.67	2.0	0.0	3	1.15
Butler	74/10/17	76/07/09	0.75	2.0	0.0	8	0.89
Licking River	75/01/25	75/06/25	2.0			1	
Catawba	74/03/14	74/12/10	1.5	4.0	0.0	6	1.5

Bacteriological Data — Total Coliform Kentucky Standard 1000/100 ml

STORET #31503 — Total Coliform Colonies per 100 ml
STORET #31616 — Fecal Coliform Colonies per 100 ml

Station	Beg. Date	End Date	Mean	Max.	Min.	OBS	S
Licking River Falmouth							
Total Coliform	75/01/06	75/12/10	7575	62600	250	19	
Fecal Coliform	75/05/07	75/12/18	1296	3700	137	8	
Licking River	75/01/21	75/12/23	470	1600	69	11	
Paris Total Coliform	75/04/15	75/12/23	688	6800	29	22	
Licking River Cynthiana							
Total Coliform	75/01/06	75/12/18	3307	20800	50	18	
Fecal Coliform	75/03/24	75/12/18	1249	8100	4	9	
Licking River Kenton Co.							
Total Coliform	75/01/06	75/12/18	2240	14800	3	18	
Fecal Coliform	75/03/25	75/12/18	574	2100	84	8	



BIG SANDY RIVER

THE BIG SANDY RIVER BASIN

The Big Sandy River Basin is the eastern most river basin in Kentucky. This basin is part of the most mountainous section of Kentucky. The first section of this report will deal with the general description of the area, both physical and population. The second section will enter into an analysis of the water quality in the basin, its causes and effects.

I. A Description of the Big Sandy River Basin

A. Geography

The Big Sandy River Basin lies in the states of Kentucky, West Virginia and Virginia. That portion of the basin which lies in Kentucky is bordered on the east by the Kentucky-West Virginia border, to the south by the Kentucky-Virginia border, and on the west by the Kentucky, Licking and Little Sandy River Basins. The western border runs through eastern Letcher County, Knott County, eastern Magoffin County, northwestern Johnson County, northwestern Lawrence County and Boyd County.

The main stem of the Big Sandy River is formed by the junction of the Tug and Levisa Forks at Louisa, Kentucky and flows northerly 27 miles to enter the Ohio River about 10 miles downstream from Huntington, West Virginia. This river enters the Ohio River 664.3 miles from the Mississippi River. It drains 4,280 square miles of which 2,285 are drained in Kentucky. The Levisa Fork rises in southwest Virginia and flows north for 34 miles in Virginia and 130 miles in Kentucky to Louisa. The Tug Fork rises in southwestern West Virginia and flows northwest about 60 miles to Kentucky, whence it forms the boundary between Kentucky and West Virginia for about 94 miles. Principal tributaries of Levisa Fork are Russell Fork (127 sq. mi.), Beaver Creek (92 sq. mi.), and Johns Creek (74 sq. mi.). There are no significant tributaries to the Tug Fork in Kentucky.

5. Topography

The character of land in the Big Sandy River Basin varies from mountainous terrain in its upper portions to hilly areas along the Big Sandy River. Over most of the area, the streams and their tributaries flow in deep, narrow, sinuous valleys between the steep-sided ridges. In the headwaters, the terrain includes the deepest gorge in the southeastern United States while in the lower portions of Boyd and Lawrence Counties the valleys are relatively wide with gently sloping hills. Physiographically, the Big Sandy River is wholly within the Appalachian Plateau.

The elevation of the Big Sandy River ranges from 2,400 feet above mean sea level (m.s.l.) (Levisa Fork) and 2,200 feet above m.s.l. (Tug Fork) at its headwaters to 498 feet above m.s.l. at its mouth on the Ohio River.

Slope, directly relates to the reaeration rate of a stream. With slopes from 0-2 ft./mi. the reaeration is low. Slopes from 3-6 ft./mi. give a medium reaeration while slopes of 7-10 ft./mi. give a high reaeration. The average slope of the Big Sandy River is 9.9 ft./mi. Slopes of the main stem, Levisa Fork below Russell Fork, and the lower 65 miles of Tug Fork average 1.3 to 2.3 ft./mi.

Many of the tributaries have a much greater average slope than the main stem. Russell Fork has an average slope of 24.9 ft./mi., Beaver Creek has an average slope of 34.3 ft./mi., Pigeon Creek has an average slope of 32.9 ft./mi., Big Creek has an average slope of 57.3 ft./mi., Peter Creek has an average slope of [illegible]3.0 ft./mi. Several other streams have average slopes of over 50 ft./mi.

C. Geology

The Big Sandy River Basin itself is not generally conducive for agricultural practices except for timber production. Generally, the soil is of limited depth, the land is steep and subject to erosion from runoff and wind. The principal geological feature of this area which directly and indirectly contributes to the water quality is the coal resource. The coal from this region is generally of metallurgical grade and suitable for production of coke. The coal has a low ash, low sulfur content and a high BTU value. The Big Sandy gas field is located in the area of the Tug and Levisa Forks. Scattered throughout the area are several small petroleum fields.

Because of the geology, the surface water of the Big Sandy River Basin is mainly sulfate-bicarbonate type with some chloride effects from oil fields in the extreme northern area around Blaine Creek and Louisa.

Aquifers are underground layers of porous rock from which ground-water is obtained. Two types of aquifers are found in the portion of the Big Sandy River Basin below the confluence of the Tug and Levisa Forks. On the eastern part of the basin, near the river, the aquifer yield is 500-1,000 gallons per minute (g.p.m.) while to the west the yield is 50 or less g.p.m. Above the confluence of the Tug and Levisa Forks, the ground water resource is characterized by the potential yield of the aquifers as follows: approximately 50 per cent of the area will produce 50 or less g.p.m., 48 per cent of the area will produce 50-500 g.p.m., and 2 per cent of the area will produce 400-1,000 g.p.m.

D. Hydrology

The stream flow of the Big Sandy Basin is shown from three gauging station records: the Big Sandy River at Louisa and the Levisa Fork at Prestonsburg and at Paintsville. The flow record summary includes drainage area, average flow, maximum and minimum flow and 7 day 10 year flow.

There are no active locks and dams on the main stem of the Big Sandy. In Kentucky the Corps has constructed two impoundments (Dewey and Fishtrap Lakes) on the Levisa Fork. The water surface totals 2,231 acres with a pool capacity of 103,000 acre feet. Both Dewey Lake and Fishtrap Lake are used for flood control, fish and wildlife, and recreation. Fishtrap Dam is also used for low flow augmentation (190 cubic feet per second).

E. Population

The population of the Big Sandy River Basin is basically rural in nature. Farms and towns are situated closely along the main stem and tributaries. The majority of population is located near the headwaters with 61,000 people residing in Pike County, 35,000 in Floyd County, and 17,000 in Johnson County. The main cities are Paintsville (Johnson) with a population of 7,300, Prestonsburg (Floyd) with 6,100, and Pikeville (Pike) with 4,900. The largest city near the mouth is Catlettsburg (Boyd County) with 3,400 people.

TABLE J-4

SURFACE WATER RECORDS FOR THE BIG SANDY RIVER BASIN

STATION	PERIOD OF RECORD	DRAINAGE AREA	AVERAGE FLOW	MAXIMUM FLOW	MINIMUM FLOW	7-day/10-yr. LOW FLOW
Levisa Fork at Prestonsburg **	13 yr.	1,701 sq.mi.	2,104 cfs, 1.2cfs*/sq.mi.	44,000 cfs, 26cfs/sq.mi.	20 cfs, 0.0cfs/sq.mi.	206 cfs
	wtr/yr 1976		1,428 cfs, 0.8cfs/sq.mi.	13,400 cfs, 7.9cfs/sq.mi.	203 cfs, 0.1cfs/sq.mi.	
Levisa Fork at Paintsville ***	49 yr.	2,143 sq.mi.	2,480 cfs, 1.2cfs/sq.mi.	69,700 cfs, 33cfs/sq.mi.	8.4 cfs, 0.0cfs/sq.mi.	210 cfs
	wtr/yr 1976		1,928 cfs, 0.9cfs/sq.mi.	14,900 cfs, 7cfs/sq.mi.	290 cfs, 0.1cfs/sq.mi.	
Big Sandy at Louisa ***	38 yr.	3,892 sq.mi.	4,425 cfs, 1.1cfs/sq.mi.	89,400 cfs, 23cfs/sq.mi.	Not determined	242 cfs
	wtr/yr 1976		3,418 cfs, 0.9cfs/sq.mi.	26,200 cfs, 6.7cfs/sq.mi.	394 cfs, 0.1cfs/sq.mi.	

* Cubic feet per second

** Flow regulated since October, 1968 by Fishtrap Lake since August, 1966 by North Fork Pound River Lake and since March, 1965 by John W. Flannagan Lake.

*** Flow regulated since October, 1968 by Fishtrap Lake since August, 1966 by North Fork Pound River Lake since March, 1965 by John W. Flannagan Lake and since May, 1950 by Dewey Lake.

NOTE: Data is taken from "Surface Water Records in Kentucky" by the United States Geological Survey. The 7-day/10-yr. low flow was taken from the waste load allocation produced as a component of the 303e River River Basin Continuing Planning Process.

II. Basin Water Quality

The basic recorded water quality of the basin is presented along with some of the major causes and effects. Also presented are the major users of surface water in the basin.

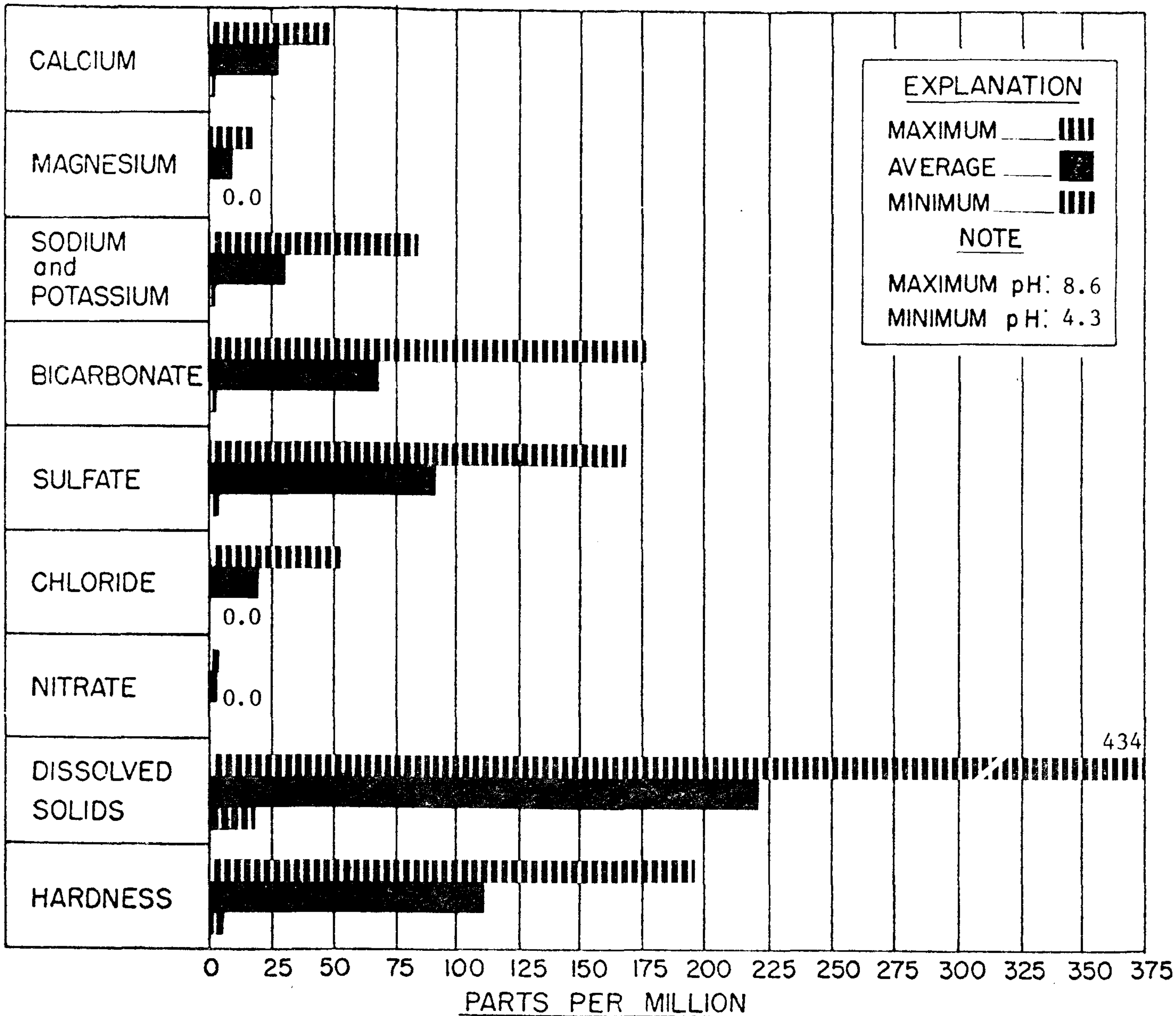
A. Description of Water Sampling Station

The U.S.G.S. station and Kentucky Water Quality Station, from which data in the following two sections was collected, are both located near Louisa, Kentucky in Lawrence County on the main stem of the Big Sandy River. The area of the basin above the stations is approximately 3,890 sq./mi., which is approximately 91% of the total basin area.

B. General Chemical Water Quality

The chemical composition of water is best defined by grouping dissolved elements which compose the total dissolved solids. By examining the relationships of groups of chemicals, the type of water whether hard or soft, salty, acid or high in sulfates reflects the mix of surface and groundwater. The chemical characteristics of a stream when viewed over a long period of time is primarily from surface water. The type of rock formation and soils which the surface water contacts causes the predominate chemical characteristics. This contribution of groundwater, which is generally higher in dissolved solids than surface water, can be shown by selecting the low flow period for data analyses. The general character of waters in Kentucky are ones which have moderate hardness caused by calcium and magnesium salts. The influence of mining activities are clearly indicated when the sulfate content increases to a higher level than the bicarbonate content, and the pH is on the acid side, below pH 5.5.

Oil field operations, when brine is encountered, are reflected by changes in sodium and chloride contents of the water. For Kentucky water, the influence



MAXIMUM, AVERAGE, and MINIMUM concentrations of dissolved constituents,

FIGURE J-1

Big Sandy River

Louisa

5-65 to 6-74

is pronounced when either chloride or sodium exceeds 20-25 parts per million as an average value. The water quality data is summarized in Table J-8 and a graph is presented to show the general chemical water quality. In the Big Sandy River Basin, the water is moderately hard in general but has ranged from soft to very hard at times. The sulfate content is, on an average, 30 per cent higher than the bicarbonate level in the streams. The pH, on an average, is within Kentucky Water Quality Standards (6-9), however, it has dropped to a recorded low of 4.3. These relationships reflect in part the influence of mining operation throughout a large portion of the basin.

The average concentration of sodium and chlorides in the stream indicates higher than expected levels which may be attributed to the activity of oil production from the Blaine Creek Basin.

C. Trace Chemical Water Quality

Trace elements (under 5 mg/l) are separated from the general chemical background of this report because of their influence on human health. Generally, these materials are "heavy" metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life. Levels for many of these elements have been established for years in the Drinking Water Standards and more recently through the State-Federal Water Quality Standards.

The standard for iron was exceeded at Paintsville on one occassion. This is possibly indicative of a surface mining runoff problem within the basin.

D. Waste Load Effect on Water Quality

Biochemical degradable wastes impose a load on the dissolved oxygen resources of a stream. Such waste loads are considered to have an adverse effect on water quality when they cause the D.O. concentration of the water to drop below the Kentucky water quality standard of 5.0 mg/l.

Waste load allocations were made for approximately 560 miles of streams using a model developed for the Kentucky Continuing Planning Process for River Basin Management Planning. The results show that approximately 250 miles would have a D.O. concentration of less than 5.0 mg/l when the flow is equal or less than the once in ten year, seven day low flow. This is attributed to the fact that in the Big Sandy Basin, the tributaries have zero flow during most years. On the main stem, approximately ten miles are affected while on the tributaries 240 miles will be affected, based on present treatment levels.

Of the stream length affected, 5 miles (2%) are affected by industry (mostly coal related), 10 miles (4%) by municipalities, and 235 miles (98%) by other discharges such as schools, trailer parks, subdivisions, etc.

The quantities of waste loads causing this effect are 80,000 gallons from industries and 520,000 gallons from municipalities.

E. Non-point Pollution

Major sources of non-point pollution of the basin's streams are coal mining and solid waste. Soil erosion from surface mined lands and forestland which has been harvested are the leading sources, followed by agricultural lands, roadbanks, streambanks, and developing areas are the main sources of sediment. Solid waste problems are a result of the lack of adequate facilities for collection and disposal of solid waste.

Areas which contribute to soil erosion are summarized as follows:

1. Strip mining, a major cause of sedimentation, is difficult to quantitate as to the area or amount. The impact in a selected area indicated the mining effects of underground and surface mining.

2. An estimated 380 sq./mi. (12% of total basin) of forest land have excessive erosion as a result of logging operations and forest fires.

3. About 4.7 sq./mi. (.2% of total basin) of cropland are eroding at rates exceeding acceptable levels.

4. About 1.6 sq./mi. (.07% of total basin) of critical area and 3,000 miles of roadbank are eroding excessively.

Most of the surface water withdrawn for usage in the Big Sandy River Basin is used for public water supply. Approximately 3.9 million gallons per day (m.g.d.) (71% of total) is withdrawn for public supply with 1.6 m.g.d. (29%) being withdrawn for industrial usage.

According to the Kentucky Department of Fish and Wildlife, the Big Sandy River Basin also includes approximately 770 linear miles of stream which have been found capable of supporting a stream fishery. Five streams (120 miles) are considered to be of outstanding quality. Streams of lesser quality total 460 miles and 190 miles have been affected by pollution. The primary form of this pollution is siltation from non-point sources.

G. Water Quality Change

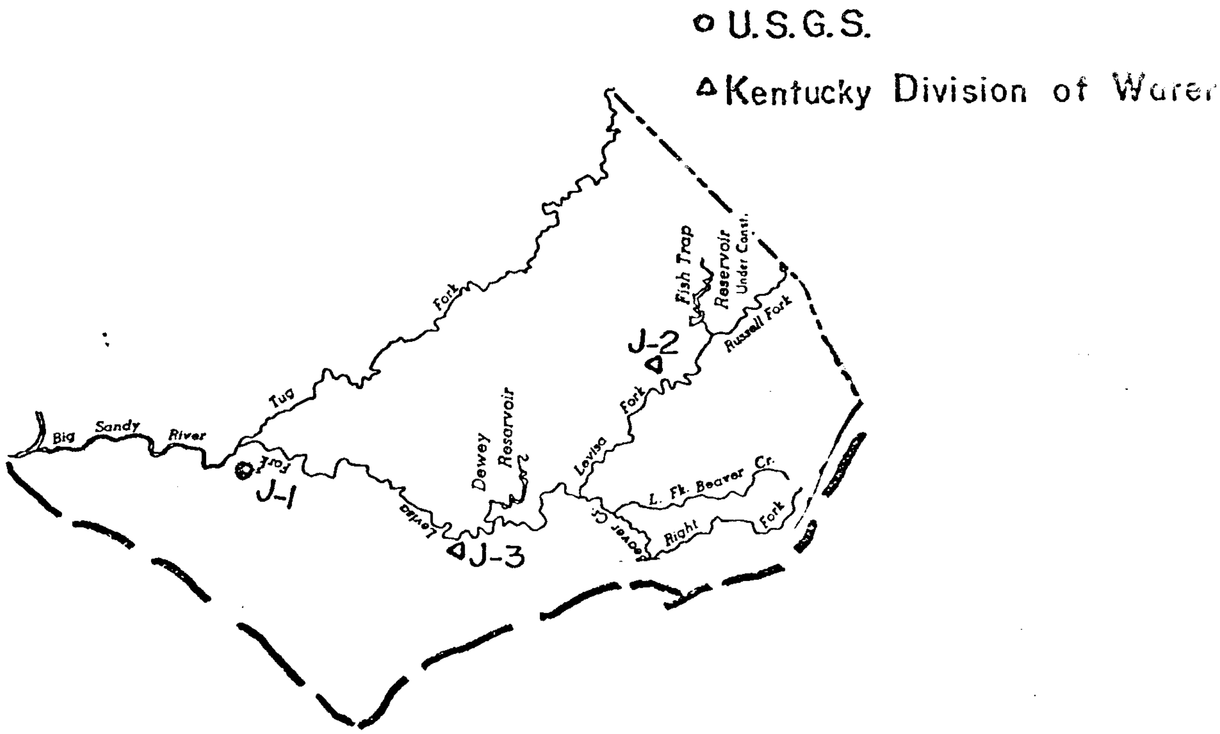
The demand for coal and the expected output from Kentucky at three times the current level or approximately 400 million tons per year foreshadows all other considerations of the Big Sandy River Basin. Even with a controlled program which can minimize the effects of sedimentation of surface mining and the effects of acid mine drainage from both surface or underground mining, water quality deterioration can be expected in the form of both siltation and a major modification of the general chemical water quality by adding to the total dissolved solids and changing the type of water from a bicarbonate to a sulfate type water.

III. Summary - Water Quality Causes and Corrections

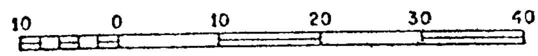
The two main problems in this basin in relation to water quality are from siltation and wasteloads.

Siltation is primarily from two aspects of the coal mine industry, logging and strip mining. Logging can result in high runoff rates and serious erosion while strip mining leads to sedimentation from upheaval of surface soil. With the increase in demand for coal due to the energy crisis, great care and vigilance will need to be exercised to see that this problem does not increase.

The problem organic discharges are from concerns such as schools, subdivisions, and trailer parks which are located on small tributaries where the low flow is often zero and the main part of the flow is often the effluent. This will be alleviated to a great extent by upgraded sewage treatment facilities.



BIG SANDY RIVER



GRAPHIC SCALE IN MILES

Base Data: U. S. Geological Survey

STATION KEY

J-1 BIG SANDY RIVER AT LOUISA
J-2 LEVISA FORK AT PIKEVILLE
J-3 LEVISA FORK AT PAINTSVILLE

TABLE J-1
Length and Drainage Areas of Streams in the
Big Sandy Basin

STREAM	MILES ABOVE MOUTH OF BIG SANDY RIVER	DRAINAGE AREA (square miles)	LENGTH IN MILES TO HEADWATERS
Big Sandy River:			
Big Sandy River	0.0	4290.0	191.0
Blain Creek	19.6	265.0	51.3
Levisa Fork:			
Levisa Fork	26.8	2331.0	164.2
Paint Creek	65.4	168.7	34.0
Johns Creek	73.7	224.1	64.1
Middle Creek	81.8	65.0	17.1
Beaver Creek	91.8	240.2	46.0
Mud Creek	102.3	52.4	12.0
Shelby Creek	123.0	115.0	20.0
Russell Fork	127.2	678.5	44.9
Elkhorn Creek	138.9	53.4	20.5
Tug Fork:			
Tug Fork	26.8	1555.0	155.3
Rockcastle Creek	37.0	120.9	33.3
Wolf Creek	63.6	83.5	16.5
Big Creek	75.6	59.4	21.0
Pond Creek	84.7	40.7	13.5
Blackberry Creek	98.9	20.2	9.5
Peter Creek	104.5	34.5	13.5

TABLE J-2

County Areas in the
BIG SANDY BASIN

COUNTY	AREA IN SQUARE MILES (1)	PERCENT AREA IN BASIN (2)	AREA IN SQUARE MILES IN BASIN
Boyd	159	27	43
Floyd	401	100	400
Johnson	264	100	260
Knott	356	28	100
Lawrence	425	92	390
Letcher	339	6	23
Magoffin	303	4	12
Martin	231	100	230
Morgan	369	10	37
Pike	786	100	790
			2,285

1. Area - U. S. Census - Source of Measurement Unknown - Approximately ± 10%

2. Percent in Basin - Federal Water Pollution Control Administration - Ohio River Basin Framework Comprehensive Study

3. USGS - Area 2,284 Square Miles - From 7.5 Minute Quadrangle Topographical Map

TABLE J-3

SLOPE CHARACTERISTICS OF BIG SANDY RIVER AND ITS PRINCIPAL TRIBUTARIES

STREAM	Elevation at source (feet above m.s.l.)	Miles above mouth of Big Sandy River	Length of Stream (miles)	Average slope (ft./mi.)
Big Sandy River	2400	0.0	191.0	9.9
A. Levisa Fork	2400	26.8	164.2	11.3
a. Russell Fork	1770	127.2	44.9	24.9
1. Pound River	2250	148.2	44.8	24.1
a. Cranesnest River	1620	154.7	24.2	13.6
b. McClure River	1620	151.5	21.0	17.6
b. Beaver Creek	1800	91.8	46.0	34.3
c. Johns Creek	1800	73.7	64.1	19.0
d. Paint Creek	1035	38.6	34.0	12.9
B. Tug Fork	2200	26.8	154.2	10.9
a. Rockcastle Creek	1050	37.0	33.3	15.3
b. Pigeon Creek	1600	68.4	30.4	32.9
c. Big Creek	1800	75.6	21.0	57.3
d. Peter Creek	1550	104.5	13.5	63.0
e. Knox Creek	1500	111.8	20.0	38.4
f. Dry Fork	2250	135.7	40.7	31.4
1. Big Creek	1700	161.1	14.4	55.5
g. Elkhorn Creek	2300	159.5	22.6	45.2
h. Panther Creek	1700	128.7	14.4	55.5
C. Blaine Creek	900	19.6	51.3	7.6

1/ Includes Levisa and Tug Forks.

TABLE J-5

LAKES OF KENTUCKY IN BIG SANDY RIVER BASIN
OVER 100 ACRES OR 1000 ACRE-FEET

NAME	COUNTY	POOL CAPACITY (AF)	AREA (AC)
Dewey Lake	Floyd	76,100	1,100
Horseford Creek Dam	Lawrence	2,510	57
Jenkins Mine Refuse Dam (owned by Beth-Elkhorn Coal Company)	Letcher	2,600	30
Fishtrap Lake	Pike	27,190	1,130
McAndrews Refuse Dam (owned by Eastern Coal Company)	Pike	2,470	17

(AF) = Acre Feet
(AC) = Acres

Table J-6

City Population and Facility Grant Status
in the Big Sandy River Basin in Kentucky

County	City	Population	Project Type	Comments
Boyd	(Catlettsburg)	3,420	1	Active
Floyd	Prestonsburg	6,100	1	Active
	Beaver-Elkhorn Water District			
	(Wheelwright)	1,781	1	Active
	(Allen)	724		
	(Wayland)	384		
	(Martin)	786		
Johnson	Paintsville-	7,300	1	Active
	(Van Lear)	1,033		
Lawrence	Louisa	1,781	1	Active
Martin	Martin Co. W. D. #1			
	(Inez)	566	1	Pending
	Martin Co. W. D. #2		1	Active
Pike	Pikeville	4,900	1	Active
	Phelps	770	None	No Sewers
	Elkhorn City	1,081	None	Sewers/STP

NOTE: Project type is related to the grant process step applied for or active for each municipality. Step 1 is the preliminary studies (201 Facilities Plan) required before design of the facilities. Step 2 is the design phase of the project, and Step 3 is the construction of facilities for the collection and treatment of wastewaters.

The comments relate to the status of the grant. Active indicates the project is funded and underway. Pending indicates that application for a grant has been made and is pending approval. No sewers indicates that the municipality does not presently have a comprehensive sewer system. Sewers/STP indicates the municipality is now served by sewers and treatment facilities.

The source of this information was the 1970 U. S. Census and the FY 77 construction grants list for Kentucky.

TABLE J-7

Population of the Big Sandy Basin

COUNTY	POPULATION IN 1970		POPULATION IN BASIN	
Boyd	52,376		8,700	
Floyd	35,889		35,889	
Johnson	17,539		17,539	
Knott	14,698		3,900	
Lawrence	10,726		9,950	
Letcher	23,165		3,800	
Magoffin	10,443		380	
Martin	9,377		9,377	
Morgan	10,019		870	
Pike	61,059		61,059	
		TOTAL	151,000	(approximate)

Table J - 8

Water Quality Data For Big Sandy River Basin

Station	Beg. Date	End Date	Mean	Max.	Min.	#OBS.	S
STORET #00400	pH Specific Units, Ky. std. 6 LT pH LT 9						
Big Sandy R - Louisa	76/01/15	76/11/11	6.7	7.5	6.2	11	.344
USGS 03215000	70/04/22	75/12/11	7.3	8.1	6.7	24	.414
	65/05/22	76/12/09	7.2	8.1	6.2	54	.469
STORET #00095	Conductivity Micro mhos Ky. std. 800 Micro mhos						
Big Sandy R - Louisa	76/01/15	76/11/11	342.2	505.0	180.0	11	117.06
USGS 03215000	70/03/11	75/12/11	360.1	580.0	150.0	38	132.7
	65/05/22	76/12/09	383.4	729.0	150.0	78	144.8
STORET #70300	Dissolved Solids mg/l Ky. std. 500 mg/l						
Big Sandy R - Louisa	76/01/15	76/09/09	229.1	312.0	104.0	9	79.2
USGS 03215000	70/04/22	75/12/11	215.2	346.0	99.0	24	76.4
	65/11/14	75/11/11	232.7	447.0	97.0	51	90.9
STORET #00410	Alkalinity mg/l No Standard						
Big Sandy R - Louisa	76/01/15	76/09/09	65.5	101.0	29.0	9	28.3
USGS 03215000	70/04/22	75/12/11	60.0	115.0	20.0	24	28.6
	65/05/22	76/11/11	61.0	123.0	20.0	47	30.0
STORET #00900	Hardness mg/l 0-60 soft, 60-120 mod.hard, 121-180 hard over 180 very hard						
Big Sandy R - Louisa	76/01/15	76/09/09	115.8	170.0	57.0	9	38.0
USGS 03215000	70/04/22	75/12/11	114.7	170.0	57.0	24	34.5
	65/05/22	76/11/11	117.9	196.0	50.0	52	37.8
STORET #00930	Sodium mg/l No Standard						
Big Sandy R - Louisa	76/01/15	76/09/09	27.7	45.0	9.0	9	14.5
USGS 03215000	70/10/14	75/12/11	27.3	53.9	7.6	16	15.5
	66/07/13	76/11/11	31.0	75.0	7.6	30	17.6
STORET # 00935	Potassium mg/l No Standard						
Big Sandy R - Louisa	76/01/15	76/11/11	2.8	3.8	1.8	9	.8
USGS 03215000	70/10/14	75/12/11	2.9	4.8	1.8	16	.9
	66/07/13	76/11/11	3.0	5.1	1.8	30	.9
STORET # 00940	Chloride mg/l Prop. E. P. A. Std. 250 mg/l						
Big Sandy R - Louisa	76/01/15	76/09/09	13.9	24.0	5.1	9	7.6
USGS 03215000	70/04/22	75/12/11	12.7	28.0	3.4	24	8.2
	65/05/22	76/11/11	16.3	52.0	3.4	52	12.3

Table J-8
Continued

STORET # 00618 — Nitrate - N mg/l Prop. E. P. A. Std. 10 mg/l

Big Sandy R - Louisa	72/01/06	72/07/24	.48	.73	.20	3	.266
USGS 03215000	66/10/11	72/07/24	.46	.73	.20	4	.219

STORET #00950 — Flouride mg/l Ky. Std. 1.0 mg/l

Big Sandy R - Louisa	76/01/15	76/09/09	.17	.30	0.0	9	.1
USGS 03215000	70/09/09	75/12/11	.14	.4	0.0	19	.1
	65/11/14	76/11/11	.14	.4	0.0	36	.1

STORET #00915 — Calcium mg/l No Standard

Big Sandy R - Louisa	76/01/15	76/09/09	27.2	40.0	14.0	9	8.8
USGS 03215000	70/10/14	75/12/11	29.3	43.0	19.0	16	9.1
	66/07/13	76/11/11	29.5	48.0	14.0	30	9.3

STORET #00945 — Sulfate mg/l Prop. E. P. A. Std. 250 mg/l

Big Sandy R - Louisa	76/01/15	76/09/09	87.6	130.0	47.0	9	28.2
USGS 03215000	70/04/22	75/12/11	92.5	150.0	42.0	24	28.9
	65/06/22	76/11/11	96.3	169.0	37.0	52	32.6

STORET #00925 — Magnesium mg/l No Standard

Big Sandy R - Louisa	76/01/15	76/11/11	11.9	16.0	5.4	10	3.7
USGS 03215000	70/10/14	75/12/11	11.9	17.0	7.6	16	3.2
	66/07/13	76/11/11	12.2	17.0	5.4	16	3.2

STORET #00080 — Color Platinum - Colbart Units Prop. EPA Std. 75 Units

Big Sandy R - Louisa	70/10/14	70/10/14	5.0	5.0	5.0	1	--
USGS 03215000	65/05/22	70/10/14	5.7	10.0	4.0	6	2.1

STORET # 01025 — Cadmium Micrograms/Liter Ky. Std. 100 ug/l

Big Sandy R - Louisa	76/01/15	76/07/22	.6	1.0	0.0	3	.577
USGS 03215000	74/04/07	76/07/22	1.0	3.0	0.0	13	.816

STORET #01056 — Manganese ug/l Prop. Ky. Std. 50 ug/l

Big Sandy R - Louisa	76/01/15	76/07/22	13.3	20.0	10.0	3	5.7
USGS 03215000	74/10/23	76/07/22	14.6	30.0	10.0	8	9.1

STORET # 01046 — Iron ug/l Prop. E. P. A. Std. 300 ug/l

Big Sandy R - Louisa	76/01/15	76/07/22	86.7	240.0	0.0	3	133.2
USGS 03215000	74/10/23	76/07/22	247.5	1600.0	0.0	8	552.2

STORET # 01030 — Chromium ug/l Ky. Std. 50 ug/l

Big Sandy R - Louisa	76/01/15	76/07/22	0.00	0.0	0.0	3	---
USGS 03215000	74/04/07	76/07/22	.92	5.0	0.0	13	1.6

Continued

STORET #01049	Lead ug/l Ky. Std. 50 ug/l						
Big Sandy R - Louisa	76/01/15	76/07/22	0.0	0.0	0.0	3	---
USGS 03215000	74/04/07	76/07/22	4.3	17.0	0.0	13	6.1
STORET #01000	Arsenic ug/l Ky. Std. 50 ug/l						
Big Sandy R - Louisa	76/01/15	76/07/22	0.00	0.0	0.0	3	---
USGS 03215000	74/04/07	76/07/22	1.23	9.0	0.0	13	2.6

Bacterialogical Data
STORET #31503 Total Coliform Colonies per 100 ml Ky. Std. 1000/100ml
STORET #31616 Fecal Coliform Colonies per 100 nl

Levisa Fork Pikeville						
T Coliform	75/02/19	75/10/30	13681	65000	10	7
F Coliform	75/20/19	75/07/30	5256	2400	0	5
Levisa Fork, Paintsville						
T Coliform	75/02/19	75/10/30	7387	15000	8	8
	75/02/19	75/10/30	7387	1220	8	8
F Coliform	72/02/19	75/07/30	830	1220	450	5
	72/02/19	75/07/30	830	1220	450	5

Water Withdrawal - Big Sandy Basin

	WATER USAGE	SW *	GW **	(Million Gallons/Day) PUBLIC	INDUSTRIAL
[illegible]					
[illegible], Kenova, [illegible] Water Co., Inc.	Big Sandy	x		1.081	.033
Calgon Corporation	Big Sandy	x	x		.007 GW .432 SW
FLOYD					
Allen Mun. Water Comm.	Beaver Creek	x		.048	.005
Francis Water Company	R. Fk. Beaver Creek	x		.033	
Kentucky Hydrocarbon	R. Fk. Beaver Creek	x			.186
Martin Municipal W. W.	Beaver Creek	x		.102	
Prestonburg Municipal Water Works	Levisa Fork	x		.356	
Beaver Elkhorn Water District		x	x	.150 GW Mar-May .159 SW June-Feb	
Island Creek Coal Co.	Beaver Creek	x			.257
JOHNSON					
Paintsville Municipal Water Works	Levisa Fork	x		.404	.101
Van Lear, Kentucky Water Company	Levisa Fork	x		.142	.003
LAWRENCE					
Louisa Municipal Water Works	Levisa Fork	x		.296	.197
LETCHER					
Jenkins, Kentucky Water Company	Elkhorn Lake	x		.578	.064
PIKE					
Feds Creek Coal Co.	Big Creek	x	x		.050 SW .005 GW
Kentland-Elkhorn Coal Company	Big Creek	x	x		.221 GW & SW
Elkhorn City Municipal Water Works	Russell Fk.	x		.066	
Pikeville Coal Company		x	x	.001 GW	.085 SW

Pikeville Municipal Water Works	Big Sandy	x	.641	033
Shelbiana (C & O Railroad)	Levisa Fk.	x	.031	.058

* SW = surface water
** GW = ground water

Contents of Lakes Report

Lakes Summary

This section represents that portion of the Water Quality Strategy in Kentucky which addresses lake water quality. It is intended as an extension of the Inventory of Lakes section in the Division of Water Quality 1974 Program Plan which is presented on the following page. The U.S. Army Corps of Engineers, as a participant in the coordinated water quality monitoring effort in Kentucky, has submitted water quality summaries for their fourteen major projects in the state. Table 1 presents a brief outline of the contents of these summaries. In addition, Table 2 presents a summary of water quality conditions at the fifteenth federal impoundment, Kentucky Lake, and a major private impoundment, Herrington Lake. The Kentucky Lake and Herrington Lake summaries were developed on the basis of limited water quality data obtained from the Tennessee Valley Authority and the Kentucky Department of Fish and Wildlife, respectively. On the basis of total area, the sixteen lakes summarized in this section represent 95 percent of the lake surface area in the state of Kentucky. Following the presentation of the Corps of Engineers lake reports is a glossary of general terms used within this section.

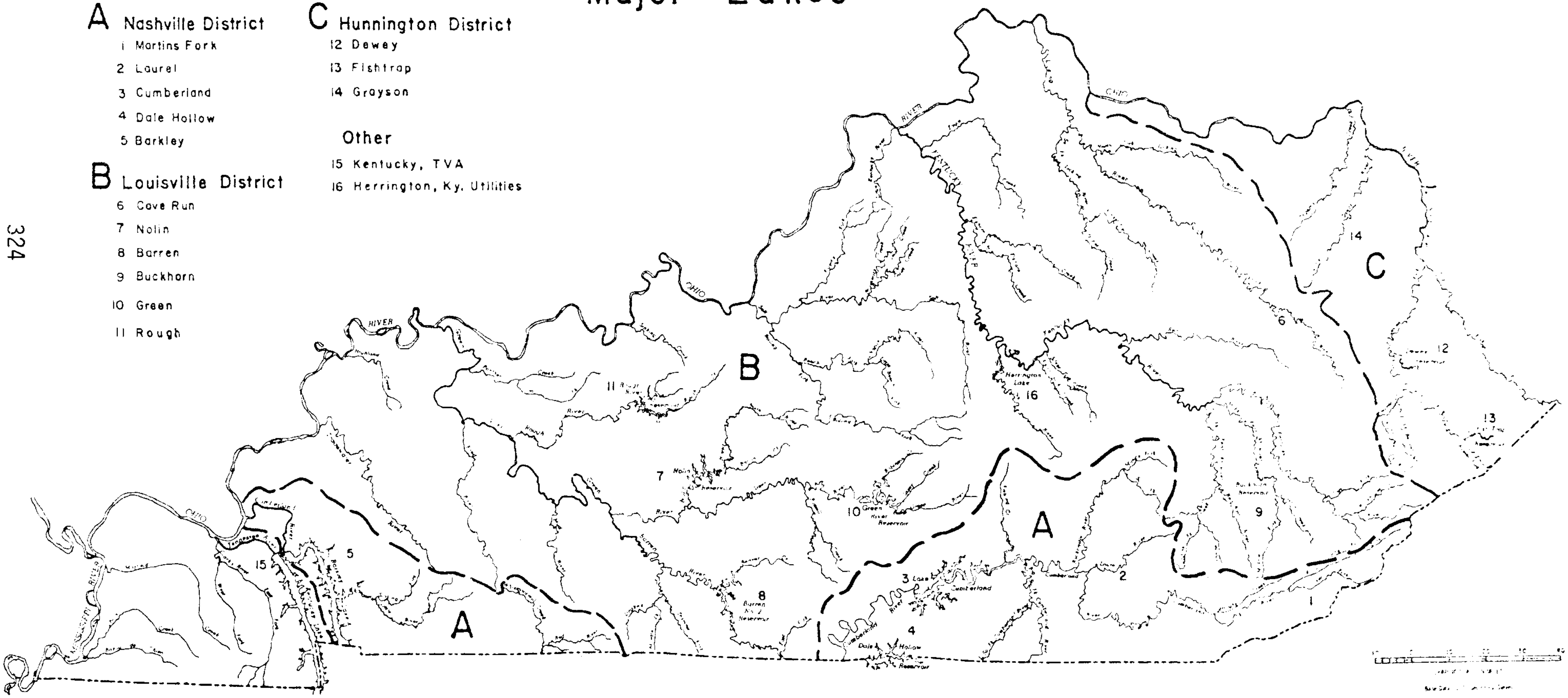
Major Lakes

A Nashville District
1 Martins Fork
2 Laurel
3 Cumberland
4 Dale Hollow
5 Barkley

B Louisville District
6 Cave Run
7 Nolin
8 Barren
9 Buckhorn
10 Green
11 Rough

C Hunnington District
12 Dewey
13 Fishtrap
14 Grayson

Other
15 Kentucky, TVA
16 Herrington, Ky. Utilities



INVENTORY OF LAKES

	Federal USCE	S.C.S. State Municipal	Private
Total number of publicity owned fresh water lakes in the state	15	153	122
Total number of significant lakes			
Number of significant lakes exhibiting noticeable eutrophy			
Number of significant lakes exhibiting no noticeable eutrophy			
Number of significant lakes for which eutrophication status is not known E. G., data is not readily available to make a determination of its eutrophic status.			
Total area of publicly owned fresh water lakes	313,961	10,109	5,830
Total area of significant lakes			
Area of significant lakes exhibiting noticeable eutrophy			
Area of significant lakes exhibiting no noticeable eutrophy			
Area of significant lakes for which eutrophication status is not known.			

1. Federal-4 of 15 were a part of the National Eutrophication Survey none of the lake exhibited noticeable eutrophy.

2. Soil Conservation Service, State & Municipal — Most are used for public water supply, are small to moderate in size (20 to 850 acre) and the cities treat the lakes for algae control which precludes a judgment on the Eutrophic status.

3. Private (excludes Herrington Lake 2940 acres owned by Kentucky Utilities). Many lakes are for fee fishing, a few for water supply. Some lakes have public access and are developed with summer cottages. The fishing lakes would tend to a mesoeutrophic or eutrophic status because of artificial fertilization.

GLOSSARY

USGS - United States Geological Survey

- Sewage Treatment Plant

Dissolved Oxygen (D.O.) - The oxygen dissolved in sewage, water, or other liquid, usually expressed in milligrams per liter (mg/l).

Oxygen Sag - A curve that represents the profile of dissolved oxygen content along the course of a stream, resulting from the deoxygenation associated with biochemical oxidation of organic matter, and reoxygenation through the absorption of atmospheric oxygen and through biological photosynthesis.

Oxycline - The region in a dissolved oxygen profile of rapid increase or decrease of dissolved oxygen concentration.

Oxygen Demand - The quantity of oxygen utilized in the oxidation of organic matter.

Thermal Stratification - A physical characteristic of lakes and reservoirs in which the temperature profile is characterized by three distinct layers called, from top to bottom: the epilimnion, the thermocline, and the hypolimnion.

Epilimnion - The upper region in a lake profile of more or less uniformly warm, circulating, and fairly turbulent water.

Hypolimnion - The lower region in a lake profile of cold and relatively undisturbed water.

Thermocline - The region in a lake profile of rapid decrease in temperature separating the epilimnion from the hypolimnion.

Isothermal Condition - A condition indicating a uniform distribution of temperature throughout a lake profile.

Fall Mixing, Fall Turnover - A seasonal phenomenon occurring in most lakes in which the cooling of surface water and inflow water decreases the resistance to mixing and thus allows the epilimnion and thermocline to mix. The effect of increased cooling and increased mixing proceeds until wind action can successfully mix the lake to its full depth.

Summer Drawdown - The process of intermittent impoundment releases for the purpose of maintaining a seasonal pool elevation.

Table L-1a
Continued

PROJECT	CORPS DISTRICT	YEAR IMPOUNDED	THERMAL STRATIFICATION	DISSOLVED OXYGEN SUMMARY	MISCELLANEOUS PARAMETER SUMMARY
CAVE RUN LAKE	LOUISVILLE	1973	Typical of tributary type impoundment in the region, having greatest impact on water quality in this lake.	Dissolved oxygen stratification develops with thermal stratification. Low hypolimnion dissolved oxygen near lake bottom.	Excessive dissolved iron and manganese concentrations produced in oxygen depleted hypolimnion. Low dissolved phosphorus concentration.
NOLIN RIVER LAKE	LOUISVILLE	1963	Typical of tributary type of impoundment in the region, having greatest impact on water quality in this lake.	Dissolved oxygen stratification develops with thermal stratification. Low hypolimnion dissolved oxygen near lake bottom.	Excessive dissolved iron and manganese concentrations produced in oxygen depleted hypolimnion. Moderated dissolved phosphorus concentration.
BARREN RIVER LAKE	LOUISVILLE	1964	Typical of tributary type of impoundment in the region.	Dissolved oxygen stratification develops with thermal stratification. Low hopolimnion dissolved oxygen near lake bottom.	Excessive dissolved iron and manganese concentrations produced in oxygen depleted hypolimnion. Low dissolved phosphorus concentration.
BUCKHORN LAKE	LOUISVILLE	1960	Typical of tributary type of impoundment in the region, having greatest impact on water quality in this lake.	Dissolved oxygen stratification develops with thermal stratification. Low hopolimnion dissolved oxygen near lake bottom.	Excessive dissolved iron and manganese concentrations produced in oxygen depleted hypolimnion. Low dissolved phosphorus concentration.
GREEN RIVER LAKE	LOUISVILLE	1969	Typical of tributary type impoundment in the region, having greatest impact on water quality in this lake.	Dissolved oxygen stratification develops with thermal stratification. Low hypolimnion dissolved oxygen near lake bottom.	Excessive dissolved iron and manganese concentrations produced in oxygen depleted hypolimnion. Low dissolved phosphorus concentration.

PROJECT	CORPS DISTRICT	YEAR IMPOUNDED	THERMAL STRATIFICATION	DISSOLVED OXYGEN SUMMARY	MISCELLANEOUS PARAMETER SUMMARY
[illegible]IVER LAKE	LOUISVILLE	1959	Typical of tributary type impoundment in the region, having greatest impact on water quality in this lake.	Dissolved oxygen stratification develops with thermal stratification. Low hypolimnion dissolved oxygen near lake bottom.	Excessive dissolved iron and manganese concentrations produced in oxygen depleted hypolimnion. Low dissolved phosphorus concentration.
[illegible]N LAKE	LOUISVILLE	1976	Typical of tributary type impoundment in this region, having greatest impact on water quality in this lake.	Dissolved oxygen stratification develops with thermal stratification, Low hypolimnion dissolved oxygen near lake bottom.	Excessive dissolved iron and manganese concentrations produced in oxygen depleted hypolimnion. Low dissolved phosphorus concentration.
DEWEY LAKE	HUNTINGTON	1950	Weak stratification during the summer.	Density layering effects cause the creation of secondary oxygen maxima in the dissolved oxygen distribution. Low hypolimnion dissolved oxygen at various levels.	Excessive levels of turbidity. High levels of iron and manganese correlating with high inflow levels. Occasional high mercury concentrations.
FISHTRAP LAKE	HUNTINGTON	1968	Weak stratification during the summer.	Density layering effects cause the creation of secondary oxygen maxima in the dissolved oxygen distribution. Low hypolimnion dissolved oxygen at various levels.	Excessive levels of turbidity. High levels of iron and manganese correlating with high inflow levels. Occasional high mercury levels in inflow and outflow.
GRAYSON LAKE	HUNTINGTON	1968	Typical of tributary type impoundment in the region.	Dissolved oxygen stratification develops with thermal stratification. Low hypolimnion dissolved oxygen near lake bottom. Outflow dissolved oxygen high due to high-level releases and stilling basin reaeration.	Excessive dissolved iron and manganese concentrations produced in oxygen depleted hypolimnion. Occasional high mercury levels.

NOTE: Biological Survey Attached.

TABLE L-1b

WATER QUALITY SUMMARY OF THE MAJOR U. S. ARMY CORPS OF ENGINEERS PROJECTS IN KENTUCKY

PROJECT	WATERSHED ACTIVITY	IMPACT OF WATERSHED ACTIVITY	PROJECT STATUS AND PLANS
MARTINS FORK LAKE	Coal Mining Project related relocation work.	Possible water quality degradation due to mining activities or project relocation work.	Future efforts include expanded sampling, installation of automatic monitoring system, and preparation of project operation manual.
LAUREL LAKE	Project power generation in Fall of 1977. Future tailwater trout fishery.	Tailwater trout stocking program may have to be delayed until a means is found to alleviate poor quality releases from oxygen depleted	Future efforts include expanded sampling in coordination with the Kentucky Division of Water Quality and studies to find a means to alleviate the problem of poor water quality releases.
LAKE CUMBERLAND	Project power releases Tailwater trout fishery	Release of turbid water in lower regions of the lake causes water in the tailwater and downstream points to appear murky.	Future efforts include a complete evaluation of all available water quality data, a better definition of inflow quality, a definition of withdrawal zone produced by power releases, and a study of reaeration by turbulence in the tailrace.
DALE HOLLOW LAKE	Coal Mining Project power releases Tailwater trout fishery	Low dissolved oxygen hypolimnetic releases create concern for tailwater trout fishery. Water quality degradation due to mining activities in the watershed particularly in the East Fork, Obey River drainage.	Future efforts include a complete evaluation of all available water quality data, a better definition of inflow quality, a definition of the withdrawal zone produced by power releases, and a study of reaeration by turbulence in the tailrace.
LAKE BARKLEY	Project power releases	No significant adverse impacts with the exception of isolated oxygen sags.	Future efforts include a study of the monitoring deficiencies and adjustment of strategy for monitoring.

TABLE L-1b
Continued

PROJECT	WATERSHED ACTIVITY	IMPACT OF WATERSHED ACTIVITY	PROJECT STATUS AND PLANS
CAVE RUN LAKE	Strip Mining Oil & Gas Wells Salyersville & West Liberty Sewage Treatment Plants	Minor water quality degradation due due to strip mining. No discernable effect from oil and gas wells in upper reaches. Negligible effect from sewage treatment plants. Problems created at Morehead Water Treatment Plant, 1 mile below dam due to poor quality releases.	Influent water quality rated as generally good, but showing some effects of strip mining. Future efforts include a study of feasible structural modifications to outlet works to eliminate releasing hypolimnetic waters.
NOLIN RIVER LAKE	Agriculture Elizabethtown & Hodgenville Sewage Treatment Plants. Tailwater Trout Fishery.	Minimal effect from sewage treatment plants No nuisance algae blooms caused by relatively high nutrient levels produced by agricultural activity.	Influent water quality rated as relatively good.
BARREN RIVER LAKE	Oil Wells Glasgow Sewage Treatment Plant Tailwater trout fishery	No discernable effect from oil wells in upper reaches. Deleterious effects (low dissolved oxygen, algae blooms, odors, etc.) on Beaver Creek arm of lake caused by Glasgow Sewage Treatment Plant. Completion of new Glasgow Plant expected to improve water quality in Beaver Creek arm of lake.	Influent water quality rated as generally acceptable with the exception of Beaver Creek.
BUCKHORN LAKE	Strip Mining Hyden Sewage Treatment Plant Tailwater trout fishery	Minor water quality degradation due to strip mining. Negligible effect from Hyden sewage treatment plant in 1976.	Influent water quality rated as acceptable, but altered somewhat from natural conditions by strip mining.
GREEN RIVER LAKE	Liberty Sewage Treatment Plant Tailwater Trout Fishery	Negligible effect from Liberty Sewage Treatment Plant.	Influent water quality rated as excellent, having been only slightly altered from natural conditions.

TABLE L-1b
Continued

PROJECT	WATERSHED ACTIVITY	IMPACT OF WATERSHED ACTIVITY	PROJECT STATUS AND PLANS
ROUGH RIVER LAKE	Agriculture Tailwater Trout Fishery Leitchfield Municipal Water intake.	No nuisance algae blooms caused by nutrients produced by agricultural activity.	Influent water quality rated as relatively good.
CARR FORK LAKE	Strip Mining	Sediment loads (attributed to strip mining) offer greatest degrading potential for water quality. No significant overall effect due to acid mine drainage during 1976.	Influent water quality rated as generally good, but showing some effects of mining activities. Sediment retention structure completed February 1976 on Defeated Creek, with others to be constructed later if studies warrant.
DEWEY LAKE	Coal Mining	Degradation of water quality due to coal mining, resulting in excessive sedimentation and metals concentrations with possibility of adverse effects on the pH regime in the near future. Severe hydrogen sulfide odors in stilling basin produced in the oxygen depleted hypolimnion.	Lake water quality rated as poor to degraded. Future efforts include an ongoing sampling program oriented toward issues pertinent to existing or potential effects of sediment movement into and through the lake.
FISHTRAP LAKE	Coal Mining Tailwater Trout Fishery	Degradation of water quality due to coal mining, resulting in excessive sedimentation and metals concentrations with possibility of adverse effects on the pH regime in the near future.	Lake water quality rated as degraded to severely degraded. Future efforts include an ongoing sampling program oriented toward issues pertinent to existing or potential effects of sediment movement into and through the lake.
GRAYSON LAKE	Coal Mining Tailwater Trout Fishery	No significant adverse impact on water quality by mining activities at this time.	Lake water quality rated as fair to good. Future efforts include monitoring programs focused at both inflow and lake stations, and cooperative studies and regulatory effort with the State of Kentucky and other appropriate agencies.

TABLE L-2a

WATER QUALITY OF OTHER MAJOR LAKES IN KENTUCKY

IMPOUNDMENT	GOVERNING AGENCY	YEAR IMPOUNDED	THERMAL STRATIFICATION	DISSOLVED OXYGEN SUMMARY	MISCELLANEOUS PARAMETER SUMMARY
KENTUCKY LAKE	TENNESSEE VALLEY AUTHORITY	1944	Pattern similar to Barkley Lake. Some period of weak stratification.	Due to thermal stratification pattern, no significant dissloved oxygen problems exist	No excessive concentrations of trace elements with the exception of occasional high levels of manganese.
HERRINGTON LAKE	KENTUCKY UTILITIES	1925	Typical of tributary type impoundment in the region.	Density layering effects cause the creation of secondary oxygen maxima in the dissolved oxygen distribution. Low hypolimnion dissolved oxygen at various levels.	Ranges of pH and alkalinity indicative of high buffering capacity of watershed. Occasional hydrogen sulfide odors occurring in low dissolved oxygen level of primary oxycline.

TABLE L-2b

WATER QUALITY OF OTHER MAJOR LAKES IN KENTUCKY

IMPOUNDMENT	WATERSHED ACTIVITY	IMPACT OF WATERSHED ACTIVITY	PROJECT STATUS AND PLANS
KENTUCKY LAKE	Project Power generation Phosphate mining on Duck River.	No significant adverse impacts on water quality by phosphate mining on Duck River or other activities in upper reaches.	Lake water quality rated as excellent. Future efforts include continued monitoring by Tennessee Valley Authority and related agencies.
HERRINGTON LAKE	Project Power Generation.	No significant adverse impacts on water quality at this time.	Future efforts include expanded monitoring in order to broaden the data base.

GLOSSARY

USGS - United States Geological Survey

- Sewage Treatment Plant

Dissolved Oxygen (D.O.) - The oxygen dissolved in sewage, water, or other liquid, usually expressed in milligrams per liter (mg/l).

Oxygen Sag - A curve that represents the profile of dissolved oxygen content along the course of a stream, resulting from the deoxygenation associated with biochemical oxidation of organic matter, and reoxygenation through the absorption of atmospheric oxygen and through biological photosynthesis.

Oxycline - The region in a dissolved oxygen profile of rapid increase or decrease of dissolved oxygen concentration.

Oxygen Demand - The quantity of oxygen utilized in the oxidation of organic matter.

Thermal Stratification - A physical characteristic of lakes and reservoirs in which the temperature profile is characterized by three distinct layers called, from top to bottom: the epilimnion, the thermocline, and the hypolimnion.

Epilimnion - The upper region in a lake profile of more or less uniformly warm, circulating, and fairly turbulent water.

Hypolimnion - The lower region in a lake profile of cold and relatively undisturbed water.

Thermocline - The region in a lake profile of rapid decrease in temperature separating the epilimnion from the hypolimnion.

Isothermal Condition - A condition indicating a uniform distribution of temperature throughout a lake profile.

Fall Mixing, Fall Turnover - A seasonal phenomenon occurring in most lakes in which the cooling of surface water and inflow water decreases the resistance to mixing and thus allows the epilimnion and thermocline to mix. The effect of increased cooling and increased mixing proceeds until wind action can successfully mix the lake to its full depth.

Summer Drawdown - The process of intermittent impoundment releases for the purpose of maintaining a seasonal pool elevation.

Glossary
Continued

Selective Withdrawal - The capability of withdrawing water of varying quality from various depths in a lake, utilizing a multilevel outlet structure.

Withdrawal Zone - That portion of a lake or reservoir located at the outlet structure and characterized by a particular water quality profile.

Trailwater - The portion of flow located just on the downstream side of a hydraulic structure.

Trailrace - A hydraulic structure for carrying the discharge from a dam to the stream channel.

Embayment - A formation resembling a bay.

Lake Morphometry - The form and structure of an impoundment.

Limnology - The science that deals with the physical, chemical, and biological properties and features of fresh waters.

Euphotic Zone - The depth through which the net effect of photosysthesis is positive.

Secchi Disc - A simple apparatus for determining the transparency of water.

Secchi Disc Depth - The depth at which a white secchi disc let down from the surface of the water just disappears from view.

Benthos - All the plants and animals living on or closely associated with the bottom of a body of water.

Non-Calcareous - The absence of calcium carbonate, calcium, or lime.

Trace Elements - Generally, these materials are heavy metals, which in sufficient concentrations have a toxic or otherwise adverse effect on human and animal or plant life.

Buffering Capacity - The capacity of a body of water to receive small amounts of acids and bases and not appreciably affect pH.

Glossary
Continued

Turbidity - A measure of fine suspended matter (usually colloidal) in liquids.

Kjeldahl Nitrogen - The total of the organic and ammonia nitrogen.

ADDENDUM TO PROJECT SUMMARIES FOR NASHVILLE DISTRICT

The water quality summaries for the Nashville District's projects in Kentucky (Martins Fork Lake, Laurel River Lake, Lake Cumberland, Dale Hollow Lake, and Lake Barkley) are unchanged from last year's report. The limited amount of data collected during 1976 did not indicate any revisions to statements concerning water quality are necessary. However, it should be pointed out that the installation of the power unit at Laurel Dam has been delayed. It is estimated that this unit will not be placed in operation until the latter half of 1977.

A coordinated monitoring program for Laurel River Lake is being developed by the Nashville District and the Kentucky Division of Water Quality and should be implemented by the spring of 1977. The Corps will be sampling lake stations on a bi-weekly basis, and the Division of Water Quality will be sampling the London and Corbin Sewage Treatment Plant effluents and headwater tributary stations on the same frequency. A fixed-station continuously recording monitor is tentatively being scheduled for installation at the power house to ascertain values of dissolved oxygen, pH, temperature, and specific conductance for power releases.

Water Quality Summary

Martins Fork Lake

The Nashville District has visited the Martins Fork project area on six occasions to collect preimpoundment water quality data. These data and data collected by other agencies have been evaluated and included in the project's General Design Memorandum (GDM). Some additional data have been collected for the District by the U. S. Geological Survey (USGS). Samples are collected by the G. S. at six week intervals and mailed to the District and Division water quality laboratories for physical and chemical analyses. The USGS also maintains a water quality monitor near the dam site, which is capable of recording hourly temperature and specific conductance values.

In addition to evaluating area water quality conditions for the GDM, the District has also performed a withdrawal zone study to design selective withdrawals ports for the dam. This report was included in the project's Feature Design Memorandum. An automatic water quality monitoring system, which will provide data on conditions in the lake and tailwater when the project is completed, has also been designed.

Recent data collected from the project area show an increase in turbidity levels and metals concentrations in Martins Fork. Whether the problem is caused by mining activities or project related relocation work is not known.

The District's future water quality efforts will include an evaluation of the water temperature data collected by the USGS to define the natural seasonal temperature regime in Martins Fork. A project operation manual will be prepared to establish operating criteria for water quality control. Periodic sampling trips will be made to monitor those activities in the watershed which will effect the water quality of the project and to expand the data base where necessary. One area of special concern with very little data is Cranks Creek, a small impoundment on a tributary to Martins Fork.

Water Quality Summary

Laurel Lake

The Nashville District has collected water samples from Laurel Lake on only one occasion. The lake was impounded in June 1974 and sampled in August 1974. The sampling trip was made to gather information on the lake and its tributaries for the project's Environmental Impact Statement. Some additional data have been obtained from one of the tributaries through the cooperation of the U.S. Geological Survey (G.S.). The samples are collected by the G.S. at six week intervals and are mailed to the District and Division water quality laboratories for chemical and physical analyses. The District has established six sampling stations in the lake, one in the tailwater and one on a tributary.

An analysis of the data collected to date shows the lake, as expected, is subject to the thermal stratification pattern typical of other tributary type impoundments in the region. The major water quality problem discovered in the August 1974 sampling run is low hypolimnion dissolved oxygen (D.O.) concentrations. Much of the oxygen demand in the hypolimnion is undoubtedly due to the vegetation and other organic materials left in the areas flooded by the lake. At present all releases from the project are from the epilimnion via the uncontrolled spillway. The project's power unit is scheduled to go on line in the fall of 1976. Since power generation will result in the release of water from the hypolimnion, there is concern over the quality of such releases.

To determine any trends in hypolimnion D.O. concentrations, the District Water Quality Unit will attempt to make at least one visit to the project in CY 1976. Sampling efforts will be intensified in CY 1977 and 1978 to establish baseline water quality data for the project. If the D.O. in the hypolimnion remains low, studies will be undertaken to find means to alleviate the problem of poor quality releases. The District will also notify the Kentucky Game and Fish Commission of the problem in case they wish to delay their tailwater trout stocking program until water quality conditions in the tailwater are improved.

Water Quality Summary

Lake Cumberland

The Nashville District has collected a reasonably good data base for physical and chemical parameter from the lower two thirds of Lake Cumberland. No data have been collected from the upper third of the lake and only a very small amount of inflow data has been obtained. The District first collected water samples from the lake in April 1971 and has sampled the project an additional fifteen times since then. Some temperature profile data have been obtained by personnel assigned to the project. Additional sources of data include state agencies in Kentucky and the U.S. Geological Survey. The District has established six sampling stations in the lake, one in the tailwater and one on a tributary.

An analysis of availbale data indicates Lake Cumberland is subject to the thermal stratification and low hypolimnion dissolved oxygen (D.O.) concentrations typical of tributary type impoundments. Although there is depletion of the hypolimnion D.O., it does not appear as severe as the depletion observed at similar District projects. Surprisingly, the lowest D.O. concentrations observed at station 3WOL20002 (one half mile upstream of the dam) were observed in April 1971 at the beginning, not the end, of stratification. From this as well as data collected in 1972 it appears the lake may not undergo complete mixing of all layers during the winter.

Another water quality problem of concern is the turbidity in the lower regions of the lake. The release of this turbid water causes the water in the tailwater and at downstream points to appear murky. The available inflow data are insufficient to determine the sources of the problem.

During FY 1976 the District awarded a contract to Tennessee Technological University to compile and evaluate all available water quality data related to Lake Cumberland. The report of this study will be used to develop a Technical Studies Work Plan (TSWP) for future water quality investigations. The District's future sampling efforts, commensurate with the TSWP, will attempt to fill in gaps in the data base for the lake and obtain a better definition of the quality of inflows into the lake. In future studies the District will define the withdrawal zone produced by project power releases and study the reaeration created by turbulence in the tailrace immediately below the powerhouse.

Water Quality Summary

Dale Hollow Lake

The Nashville District's sampling program has established a reasonably good data base for physical and chemical parameters in Dale Hollow Lake. A small amount of data has also been collected from the major tributaries. No biological data have been obtained from either the lake or the tributaries. The District first collected water samples from the lake in April 1971 and has visited the project an additional thirteen times since then. In addition a good base of temperature profile data has been obtained by project personnel. Other sources of data include Tennessee Technological University, the Fish and Wildlife Service, the Environmental Protection Agency and state agencies in both Tennessee and Kentucky. The District has established nine sampling stations in the lake, one in the tailwater and six on tributaries to the lake.

The thermal stratification pattern in Dale Hollow is typical of other tributary type impoundments in the region. Dissolved oxygen (D.O.) profiles collected at station 3DAL20002 (about one half mile above the dam) show that D.O. concentrations in the hypolimnion approach zero in the deepest portions of the lake in the fall. This problem is of particular concern at Dale Hollow because of the tailwater trout fishery. One sample collected by the Water Quality Unit at station 3DAL10001 showed the tailwater D.O. concentration was less than 3 mg/l.

Another water quality problem of concern is the degradation of inflows due to mining activities in the watershed. The problem appears to be most severe in the East Fork, Obey River drainage. However, samples collected from the East Fork embayment show only a minor influence from mining activities on the quality of water in the embayment. The District Water Quality Unit has investigated two fish kills in the embayment and found both were due to a sudden change in water temperature caused by thunderstorm activity.

During FY 1976 the District awarded a contract to Tennessee Technological University to compile and evaluate all available water quality data related to Dale Hollow. The report generated by this study will be used to develop a Technical Studies Work Plan for future water quality investigations. The District's future sampling efforts will be aimed at filling in gaps in the water quality data base for the lake and in obtaining a better definition of the quality of inflows into the lake. In future studies the District will define the withdrawal zone produced by project power releases and study the reaeration caused by turbulence in the tailrace immediately below the powerhouse.

Water Quality Summary

Lake Barkley

The Nashville District has collected very little water quality data from Lake Barkley. The Water Quality Unit has collected samples from the lake on only two occasions since the project was first visited in October 1971. Additional sources of water quality data include the U. S. Geological Survey (tailwater, the Tennessee Valley Authority (data from the vicinity of Cumberland Steam Plant) and state agencies in Tennessee and Kentucky. The District has established seven sampling stations in the lake and one in the tailwater.

An analysis of the water quality data collected to date indicates Lake Barkley does not stratify. In the upper reaches of the lake current velocities generate sufficient turbulence to prevent stratification. By the time the water reaches the lower portion of the lake, where velocities are much lower, it has been exposed to atmospheric conditions for several days and, like the surface layers, is near equilibrium temperature. This factor and the low storage volume versus flow relationship insures fairly uniform temperatures in depth profiles.

The District's sampling program has revealed only one water quality problem of concern. During one of the sampling trips dissolved oxygen concentrations at station 3BAR10005 (near the middle of the lake) were found to be below 5 mg/l from surface to bottom. The cause of this oxygen sag is not known.

The District's water quality data base for Lake Barkley is generally poor. However, before the present sampling program is revised, a detailed survey of data available from other agencies will be made. These data will be analyzed to determine specific problems and outline areas in which more data are needed. The District's sampling program will be designed to fill in the gaps in the existing data base and to define the extent and causes of water quality problems. Once sufficient amount of data has been collected, means of alleviating the problems will be studied.

CAVE RUN LAKE
1976 WATER QUALITY SUMMARY

The water quality of Cave Run Lake was monitored monthly by the Corps. Beginning from spring through fall, temperature profiles were taken weekly near the dam.

Influent water quality was generally good, but did show some effect of the strip mining activities in the basin; total iron concentrations during 1976 at the main inflow sampling station averaged 1,381 ug/l (and turbidity also was occasionally high). Oil and gas wells in the upper part of the basin produced no discernible effect on water quality. The only major point sources, sewage treatment plants at West Liberty and Salyersville, are so far above the lake that their effect on lake water quality was also negligible.

Thermal stratification probably had the greatest impact on lake water quality. In 1976 stratification began about the last week in April and reached a maximum around the middle of July, with a temperature difference from top to bottom of 29 degrees F. (81 to 52 degrees in 60 feet). During most of the summer the epilimnion was 10 to 20 feet deep.

Surface temperatures began a gradual decline about the first of September; however, stratification was very evident and clearly defined up through the first week in October. The lake was completely destratified by the end of October.

Dissolved oxygen stratification began to develop when temperature stratification began. During most of the summer the dissolved oxygen remained near saturation from the surface to a depth of 10 to 20 feet, corresponding to the depth of the epilimnion created by thermal stratification. Near the bottom, the dissolved oxygen was practically zero, until thermal destratification began.

The reducing environment produced in the oxygen-depleted hypolimnion caused iron and manganese to be reduced to soluble ionic species. During midsummer to early fall, dissolved iron and manganese in the hypolimnion were present above EPA recommended limits for drinking water, reaching 4,200 ug/l and 3,100 ug/l, respectively. No health hazard was involved and since there are no water supply intakes in the lake, increased iron and manganese did not cause problems in the lake itself. However, it was necessary to release hypolimnetic waters during the summer, and these releases again created problems at the Morehead water treatment plant. Excessive dissolved manganese reached the treatment plant intake about 1 mile below the damsite. Modifications were made in operational procedure at the dam to minimize the extent and duration of the problem for Morehead, but the condition persisted until the breakup of stratification in late October. The Corps of Engineers is currently studying feasible structural modifications for the outlet works that will eliminate the necessity for releasing hypolimnetic waters.

Nuisance algae blooms were not a problem in Cave Run Lake. Dissolved phosphorus in the euphotic zone did not reach concentrations which would encourage such nuisance growths during 1976. The average Secchi disc reading for the summer was 110 inches.

NOLIN RIVER LAKE
1976 WATER QUALITY SUMMARY

The water quality of Nolin River Lake was monitored monthly by the Corps. From spring through fall, temperature profiles were taken weekly near the dam.

Influent water was of relatively good quality. Agricultural activities had the most influence on water quality; total phosphorus concentration at the main inflow sampling station averaged 93 ug/l during 1976. Total iron concentrations were slightly high (average of 791 ug/l). The only important point sources in the basin are the sewage treatment plants at Elizabethtown and Hodgenville, which are far enough upstream from the lake that their effects were minimal.

Thermal stratification probably had the greatest impact on lake water quality. In 1976 stratification began about the first of May and reached a maximum around Mid-July with a temperature difference from top to bottom of 27 degrees F. (81 to 54 degrees in 95 feet). During most of the summer the epilimnion was 10 to 20 feet deep.

Surface temperature began to decline after the first part of September, but stratification was well defined up until the end of September when a decrease in intensity of stratification became evident. The lake was essentially destratified by the end of October.

Dissolved oxygen stratification began to develop when temperature stratification began. During most of the summer the dissolved oxygen remained near saturation from the surface to a depth of approximately 15 feet, corresponding to the depth of the epilimnion created by thermal stratification. The dissolved oxygen in the hypolimnion gradually declined until, during July and August, the concentration below 25 feet was essentially zero. The lake remained stratified with respect to dissolved oxygen until the middle of November.

The reducing environment produced in the oxygen-depleted hypolimnion caused iron and manganese to be reduced to soluble ionic species. During most of the summer, dissolved manganese in the hypolimnion was present at concentrations above EPA recommended limits for drinking water, reaching 2,600 ug/l, in early September. Dissolved iron in the hypolimnion was above EPA recommended limits for drinking water for 2 months, September and October, reaching a maximum of 3,160 ug/l in early October. No health hazard was involved and since the lake is not used as a source of raw water, the increased iron and manganese did not interfere with project purposes. Occasionally, temporary releases of bottom waters were necessary during summer drawdown, but produced no major problems.

Nuisance algae blooms were not a problem in Nolin River Lake, even though dissolved phosphorus in the euphotic zone did reach concentrations which could encourage such nuisance growths during 1976 in late spring and early summer. The average Secchi disc reading for the summer was 106 inches.

BARREN RIVER LAKE
1976 WATER QUALITY SUMMARY

The water quality of Barren River Lake was monitored monthly by the Corps. From spring through fall, temperature profiles were taken weekly near the dam.

Influent water quality was generally acceptable with the exception of Beaver Creek. Beaver Creek receives the effluent from the Glasgow sewage treatment plant, which contributes excessive organic materials and nutrients to that arm of the lake. 1976 monitoring activities revealed inflow BOD loading to this arm of the lake up to about 150 mg/l. However, Glasgow has a new sewage treatment plant near completion that will undoubtedly improve the situation in Beaver Creek. Numerous oil wells in the upper part of the basin produced no discernible effects on water quality.

Thermal stratification began to form in the last week of April and reached a maximum around the end of August, with a temperature difference from top to bottom of 23 degrees (81 degrees to 58 degrees in 64 feet). During most of the summer the epilimnion was 15 to 20 feet deep.

Surface temperatures began to decrease around the middle of September, at which time stratification also began to decrease in intensity. Destratification was complete by the middle of October.

Dissolved oxygen stratification began to develop when temperature stratification began. During most of the summer of 1976 the dissolved oxygen remained near saturation from the surface to a depth of 15 to 20 feet, corresponding to the depth of the epilimnion formed by thermal stratification. Below 30 feet the dissolved oxygen was practically zero until thermal destratification began.

The reducing environment produced in the oxygen-depleted hypolimnion caused iron and manganese to be reduced to soluble ionic species. As stratification became more intense during the latter part of the summer, dissolved iron and manganese in the hypolimnion increased above the EPA recommended limits for drinking water, reaching concentrations of 2,240 ug/l and 4,100 ug/l, respectively, in early September. No health hazard was involved and the increased iron and manganese did not interfere with project purposes.

During the summer and fall of 1976, emergency stilling basin repairs required the pool level to be lowered by 13 feet. The lowering of the pool began around the first of August and ended about the first of October. During the period of repair (Oct-Dec), release was limited to about 5 cfs. Releases of bottom waters were necessary during the summer drawdown, but produced no major problems. Releases were coordinated with the Bowling Green water treatment facility in order to avert possible problems.

Nuisance algae blooms were not a problem during 1976. Dissolved phosphorus in the euphotic zone did not reach concentrations which would encourage nuisance growths. The average Secchi disc reading for the summer was 90 inches.

BUCKHORN LAKE
1976 WATER QUALITY SUMMARY

The water quality of Buckhorn Lake was monitored monthly by the Corps. During the warm part of the year, temperature profiles were taken weekly near the dam.

Influent water quality was acceptable, but showed alteration from natural conditions; apparently strip mining in the basin has caused an increase in influent concentrations of iron and manganese, sulfate, and turbidity. This deterioration in quality has not seriously affected the quality of lake water. The only important point source of domestic sewage in the basin is the Hyden sewage treatment plant. The effect of this plant on lake water quality during 1976 did not produce any significant problems.

Thermal stratification probably had the greatest impact on lake water quality. In 1976, stratification began about the middle of April and reached a maximum around the end of July with a temperature difference from top to bottom of 22 degrees (82 degrees to 60 degrees). During most of the summer the epilimnion was 10 feet to 15 feet deep.

Surface temperatures began to decrease gradually after the middle of September, with the lake being nearly destratified by the middle of October.

Dissolved oxygen stratification began to develop when temperature stratification began. During most of the summer of 1976. the dissolved oxygen remained near saturation from the surface to the depth of the epilimnion created by thermal stratification. Below 30 feet, the dissolved oxygen was practically zero until thermal destratification began.

The reducing environment produced in the oxygen-depleted hypolimnion caused iron and manganese to be reduced to soluble ionic species. As stratification became more intense during the latter part of July, dissolved manganese in the hypolimnion increased above EPA recommended limits for drinking water. During September, both metals exceeded the recommended limits at depths below 40 feet and reached maximum concentrations of 3,800 ug/l and 2,200 ug/l, respectively, near the bottom. No health hazard was involved and since the lake is not used as a source of raw water, the increased iron and manganese did not interfere with project purposes. Occasionally, temporary releases of bottom waters were necessary during summer drawdowns, but produced no major problems.

Nuisance algae blooms were not a problem and dissolved phosphorus in the euphotic zone did not reach concentration which would encourage nuisance growth during 1976. The average Secchi disc reading for the summer was 81 inches.

GREEN RIVER LAKE
1976 WATER QUALITY SUMMARY

The water quality of Green River Lake was monitored monthly by the Corps. From spring through fall, temperature profiles were taken weekly near the dam.

Influent water quality was excellent and appears only slightly altered from natural conditions. The only important point source in the basin is the Liberty sewage treatment plant, which has a very negligible effect on lake water quality.

Thermal stratification had the greatest impact on lake water quality. In 1976, stratification began about the third week in April and reached a maximum around the first of August, with a temperature difference from top to bottom of 28 degrees F. (82 degrees to 54 degrees in 75 feet). During most of the summer the epilimnion was 15 feet to 20 feet deep.

Surface temperature began to decrease significantly after the middle of September and the lake was essentially destratified by the end of October.

Dissolved oxygen stratification began to develop when temperature stratification began. During most of the summer of 1976, the dissolved oxygen remained near saturation from the surface to a depth of 10 feet to 20 feet, corresponding to the depth of the epilimnion created by thermal stratification. Dissolved oxygen concentrations in the hypolimnion gradually decreased over the summer until, by the first of August, the concentration in depths below 30 feet was essentially zero. Low dissolved oxygen concentrations near the bottom continued through October.

The reducing environment produced in the oxygen-depleted hypolimnion caused iron and manganese to be reduced to soluble ionic species. Concentrations of dissolved manganese in the hypolimnion were above EPA recommended limits for drinking water during the entire summer. During September and October, both metals exceeded the recommended limits at depths below 20 feet and reached maximum concentrations of 7,700 ug/l and 3,500 ug/l, respectively, near the bottom. No health hazard was involved and since the lake is not used as a source of raw water, the increased iron and manganese did not interfere with project purposes. Occasionally, temporary releases of bottom waters were necessary during summer drawdown, but produced no major problems.

Nuisance algae blooms were not a problem in Green River Lake. Dissolved phosphorus in the euphotic zone did not reach concentrations which would encourage such nuisance growths during 1976. The average Secchi disc reading for the summer was 83 inches.

ROUGH RIVER LAKE
1976 WATER QUALITY SUMMARY

The water quality of Rough River Lake was monitored monthly by the Corps. From spring through fall, temperature profiles were taken weekly near the dam.

Influent water is of relatively good quality. Although agriculture is the main land use of the basin and probably produces the most effect on water quality, nutrient inflow during 1976 was not high. Total phosphorus concentrations at the main inflow sampling station averaged 55 ug/l. Total iron concentrations were high, averaging 1,843 ug/l. There are no important point sources of domestic sewage in the basin.

Thermal stratification probably had the greatest impact on lake water quality. In 1976, stratification began to form during the last week of April and reached a maximum around the end of July, with a temperature difference from top to bottom of 27 degrees F. (85 degrees to 58 degrees in 65 feet). During most of the summer the epilimnion was 10 feet to 16 feet deep.

Surface temperatures began to decrease after the middle of September; intensity of stratification started to decrease during the last week of September and the lake was essentially destratified by the third week of October.

Dissolved oxygen stratification began to develop when temperature stratification began. During most of the summer the dissolved oxygen remained near saturation from the surface to a depth of 10 to 15 feet, corresponding to the depth of the epilimnion created by thermal stratification. Dissolved oxygen concentrations in the hypolimnion decreased rapidly in early summer until, by the middle of June, the concentration in depths below 20 feet was essentially zero. Low dissolved oxygen concentrations near the bottom continued through September.

The reducing environment produced in the oxygen-depleted hypolimnion caused iron and manganese to be reduced to soluble ionic species. As stratification became more intense, dissolved iron and manganese in the hypolimnion increased above EPA recommended limits for drinking water. During the period of thermal stratification, both metals exceeded the recommended limits at depths below 25 feet and reached maximum concentrations of 2,700 ug/l and 2,700 ug/l, respectively, near the bottom. No health hazard is involved with iron and manganese. Occasional temporary releases of bottom waters were necessary during summer drawdown, but no major problems were produced downstream.

Nuisance algae blooms were not a problem in Rough River Lake. Dissolved phosphorus in the euphotic zone did not reach concentrations which would encourage such nuisance growths during 1976. The average Secchi disc reading for the summer was 79 inches.

CARR FORK LAKE

1976 WATER QUALITY REPORT

Carr Fork Lake was put into operation in January 1976. Beginning in June the water quality was monitored monthly by the Corps. From early April through mid-October, temperature profiles were taken weekly near the dam.

Influent water quality was generally good, but did show some effects of the strip mining activities in the basin. Total iron concentrations during 1976 at the main inflow sampling station averaged 1715 ug/l. Some tributaries of Carr Fork Lake are degraded by acid mine drainage, but the overall effect upon the lake was not a significant factor during 1976. Tributaries having high sediment loads (attributed to strip mining) offer the greatest degrading potential for the water quality of the lake. A sediment retention structure was completed in February 1976 to trap sediment from the Defeated Creek tributary and others are under study and may be built if needed. There are no important point sources of domestic sewage in the basin.

Thermal stratification probably had the greatest impact on lake water quality. In 1976, stratification began near the last of April and reached a maximum about the last week in July, with a temperature difference of 30.5 degrees F. (81.5 to 51 degrees in 65 feet). During most of the summer the epilimnion was 10 to 20 feet deep. Surface temperature began a gradual decline about the middle of September; however, stratification was evident and clearly defined through the second week of October. The lake was completely distratified by the end of October.

Dissolved oxygen stratification began to develop when temperature stratification began. During most of the summer, dissolved oxygen remained near saturation from the surface to a depth of 10 to 20 feet, corresponding to the depth of the epilimnion created by thermal stratification. Near the bottom, the dissolved oxygen was practically zero, until thermal distratification began.

The reducing environment produced in the oxygen depleted hypolimnion caused iron and manganese to be reduced to soluble ionic species. During most of the summer, dissolved iron and manganese in the hypolimnion were present in concentrations above EPA recommended limits for drinking water, reaching 1,050 ug/1 and 1,645 ug/1, respectively. No health hazard was involved and since there are no water supply intakes located in the lake proper, increased iron and manganese did not cause problems within the lake.

Nuisance algae blooms were not a problem in Carr Fork Lake in 1976. Dissolved phosphorus in the euphotic zone did not reach concentrations which would encourage such nuisance growths during the year. The average Secchi disk reading during the 1976 monitoring activities was 79 inches.

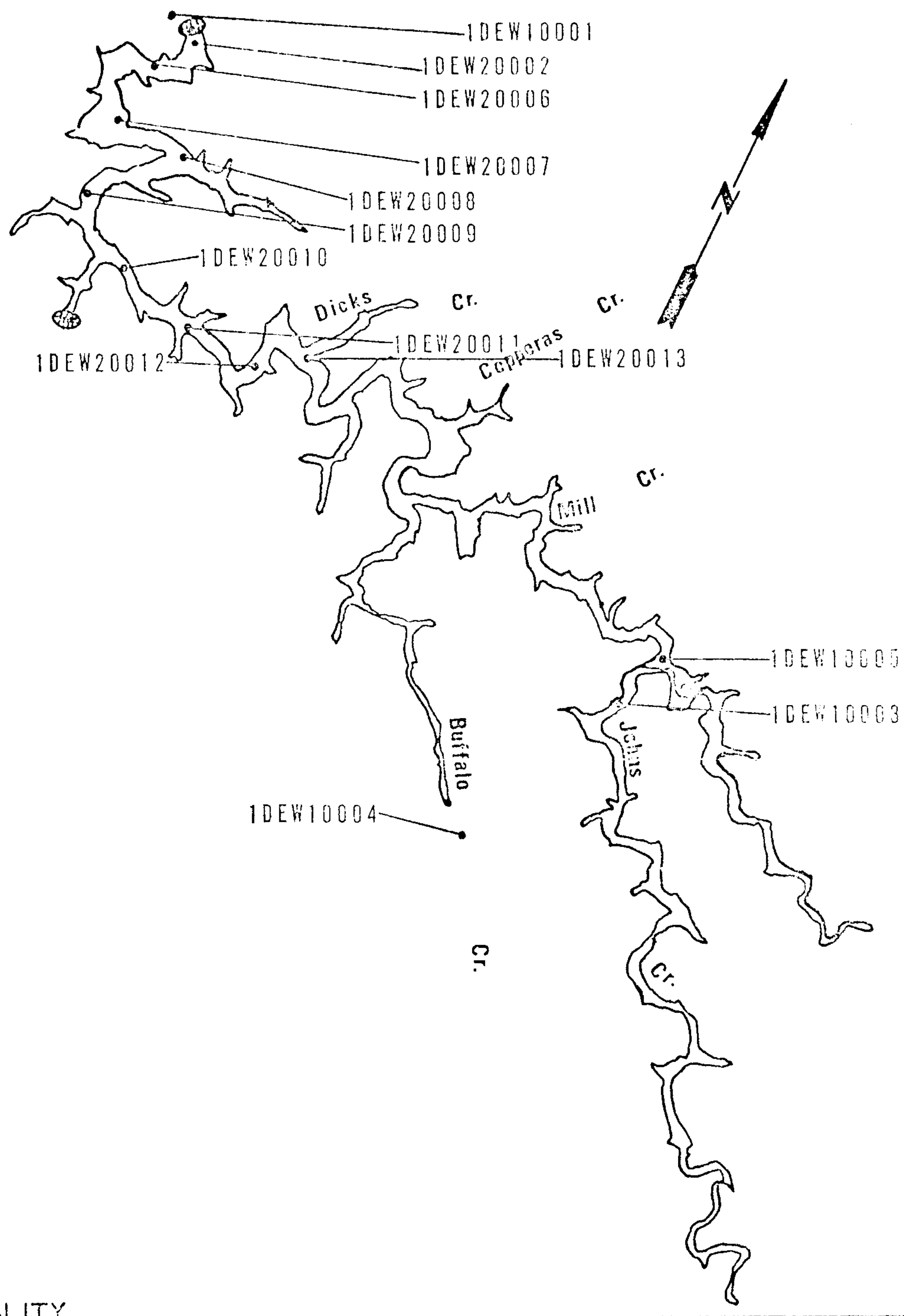
1.0 Sampling Schedule

Physical-chemical samples were collected at Dewey Project inflows, the lake and outflows on a monthly basis during the periods of anticipated thermal stratification and at least once during the winter period. In 1974, lake sampling was done at one station near the dam, and in 1975 and 1976 at this station and others at selected intervals upstream in the lake. These intervals were selected to provide insight into the areal and volumetric extent of hypolimnetic water. Selected inflows and the outflow were sampled on the same frequency as lake stations. Sampling dates for 1974, 1975, and 1976 are shown in Table 1-1 and sampling locations in Figure 1-1.

TABLE 1-1

WATER QUALITY SAMPLING SCHEDULE FOR DEWEY PROJECT - 1974-1976

	J	F	M	A	M	J	J	A	S	O	N	D
1974			X			X	X			X		X
1975	X		X			X		X		X		
1976					X		X	X		X		



WATER QUALITY
SAMPLING STATIONS

JOHNS CREEKS
DEWEY LAKE
KENTUCKY
GENERAL LOCATION MAP
SCALE IN MILES
1 0 1 2

FIGURE 1-1

2.0 Contemporary Water Quality

2.1 Physical-Chemical Results

2.1.1 Temperature

Thermal and chemical stratification effects at Dewey Lake during summer months exert direct influences on water quality. Late fall and early spring are transition periods between stratification effects in summer and nearly uniform conditions relative to distribution of various properties, such as temperature and dissolved oxygen, in winter.

Temperature profiles near the dam did not show strong thermocline formation in summer months, although inflections in temperature distribution were noted at depths of 5 to 15 feet. These inflections correlated with sharp changes in the distribution of dissolved oxygen and suspended materials. Temperatures in the hypolimnion were relatively uniform and, below the inflection, decreased slowly toward the bottom.

Isothermal or nearly isothermal condition develops in the fall and persist through the winter, as shown in the lake's behavior during the period of October 1974 through March 1975. Thermal stratification conditions were then resumed by the lake during the summer of 1975.

2.1.2 Dissolved Oxygen

The behavior of dissolved oxygen in Dewey Lake is quite complicated, and apparently reflects effects of inflowing water and various mechanisms within the lake itself. At times, the water column below the inflection point in temperature was devoid of oxygen, and at other times oxygen paralled the generally slow decrease in temperature toward the bottom.

No multi-level outlets exist for blending of waters from various depths in the lake near the dam. As a consequence, discharges must be made from deep within the lake of from the surface.

Distribution of temperature and dissolved oxygen directly affect various materials present in the lake water during stratification periods. For example, the odor of H_2S was at times severe at the stilling basin during summer months. Dissolved oxygen levels deep in the lake were effectively zero at these times.

2.1.3 Metals

Levels of iron and manganese are relatively high at times in the outflow and hypolimnion during stratification periods, and the present design of the outflow structures permit only limited blending from near bottom and surface elevations of the lake. Since levels of total iron correlated with "turbidities" and suspended solids, it is felt that iron is associated with suspended materials in inflow waters. Dissolved iron was always only a small fraction of total iron. Data seem to suggest that maganese, for the most part, enters the project in the dissolved form and exists with little discernable change. Levels of total mercury as high as 10.0 ug/l occurred in the lake although the average level is about 3 ug/l. The source and significance of the transient values are being evaluated. No definitive temporal trends are obvious for any of these metals.

2.1.4 pH and Alkalinity

The range of pH (5.7 to 8.9) and relatively low values of alkalinity are representative of low buffering capacity and are typical for the predominately non-calcareous nature of this watershed. Although no deleterious shifts were noted in either of these parameters, it is anticipated that the pH regime might be adversely impacted by mining activities.

2.1.5 Nutrients

For purposes of the fishery and food chain within the lake, it appears that phosporus is a limiting nutrient.

2.1.6 Optical Properties of Water and Suspended Materials

Optical properties of water may be evaluated for such limnological purpose as study of stratification, turbidity, particle size distribution of suspended solids, and plankton layer depths. Light transmissivity in water is one technique used to evaluate optical properties of this fluid. Measurements are made of effects of suspended material on a beam of light traveling along a fixed pathway. Light transmission or attenuation varies in response to transparency of the water.

Instrumentation of the type described above was used to evaluate levels of water transparency (i.e., levels of suspended materials) in the water column at Dewey Lake in 1975. Because of the various performance and readout characteristics of the instrument which was used, it is felt that data is of use only for ascertaining patterns of distribution of suspended material (quantitive evaluations).

Results of in situ profiles (together with laboratory analyses of suspended solids) taken at selected intervals upstream from the dam indicate that apparent density layering effects occur within the lake; i.e., layers of water containing relatively high levels of suspended solids existed in the lake at the time of sampling.

2.2 Biological Results

A total of 6 benthic macroinvertebrate samples have collected and analyzed from the outflow station at Dewey Lake from July 1974 to September 1976. Species diversity (Shannon-Weaver) was greater than 2.0000 on occasions; the mean value for 1976 was 2.0004 indicating moderately good water quality. Equitability fluctuated from 1.21 to 0.50, an indication of the somewhat unstable environment associated with the outflow of the reservoir. Population density was determined on only one occasion and was 10.5 organisims per square foot. Dominant types of organisms present were ephemeropterians and dipterians. A lack of net spinning filter feeders was noted indicating the water discharged contained low concentrations of planktonic biomass or that water quality conditions were insufficient to maintain a significant population of these organisms.

Benthic macroinvertebrate samples were collected at the main inflow station on Johns Creek on 7 occasions from July 1974 to September 1976. Results of analysis indicate that the population is unstable due to some stress factor associated with its environment. With a minimum species diversity of 0.000 and a maximum of

3.367 in June 1975, substrate is eliminated as a supression factor; the mean for 1976 was 1.8734. Equitabity varied from 0.00 (July 1974) to 0.09 (August 1975). The mean value in 1976 was 0.41 indicating definite suppression of the population, on two occasions in 1976 and in both cases was over 100 per square foot.

During 1975 the population was dominated by an Ephemeropterian - Coleopterian fauna, but in 1976 dipterians were dominant during the same season of the year.

Since dipterians are generally considered more tolerant of poor water quality it is assumed that conditions have degraded in 1976. Increases in mining activity and probable increases in suspended solids and turbidity are believed responsible for the degradation and associate supression of the fauna at the primary inflow.

Buffalo Creek inflow, sampled on seven occasions from July 1974 to October 1976, seems to have a more stable fauna. Diversity ranged from 1.000 (July '74) to 3.2135 (January 1975). The mean value in 1976 was 2.7933, highest in the basin and indicative of a relatively stable population and relatively good water quality. Equitability also indicated a more stable system (mean = 0.65) Density was not documented. The population was totally terminated in 1975 by a ephemeropterians and dipterians in 1976; however, significant numbers of tricopterians and megalopterians (less tolerant to stress) were found.

Brushy Creek inflow was sampled to infrequently to allow trend analysis.

3.0 Summary

Excessive sedimentation could be the most significant problem affecting normal operation and management of the Dewey Lake Project. Coal mining in the project watershed is the primary source of the problem. Preliminary results indicate that inflow of sediment from the watershed to Dewey Lake might be causing "turbidity" and sedimentation problems which could overshadow effects of most other within the pool. These effects are reflected in the distribution of temperature, dissolved oxygen, and suspended materials. Relvatively high levels of suspended materials occurred below depths of about 20 feet in the summer of 1975.

When results are considered as a whole, the water quality of the lake is considered as degraded. Continued adverse environmental effects from mining activities can only serve to cause continuance or deterioration of the situation.

4.0 Ongoing Sampling Program

Specifically, the ongoing sampling program will be oriented toward issues pertinent to existing or potential effects of sediment movement into and through the lake. Generally, the program is structured to describe, either separately or in combination, the various factors at the project which affect water quality. An interdisciplinary approach will be used to evaluate the physics, chemistry, and biology of inflow streams, the lake, and the outflows.

The basic study consists of four essential components: (1) in situ measurements to evaluate distribution of various properties in the lake, (2) chlorophyll and total organic carbon measurements, (3) biological measurements, and (4) wet chemistry and various types for both immediate and long-term use, chlorophyll and total organic and chemical laboratory types of analyses for long-term use.

Properties of paramount importance for purposes of the program include factors pertinent to water density, physical/chemical systems or maintenance of life and optical properties. Measurements of optical properties (light transmissivity or scattering) in water can be used for such purpose as evaluating stratification, plankton layer depth, "turbidity" estimation of particle size distribution, and estimation of suspended solids concentrations.

Benthic organism will be used, especially with respect to sedimentation effects, to monitor changing condition in the watersheds of inflowing streams.

Chemical and physical parameters relevant to effects of sediment, such as metals and suspended solids, will be monitored on a routine basis.

FISHTRAP PROJECT

1.0 Sampling Schedule

Physical-chemical samples were collected at Fishtrap Project at inflows, the lake and outflows on a monthly basis during the periods of anticipated thermal stratification and at least once during the winter period. In 1975 and 1976 lake sampling was done at one station near the dam and another at selected intervals upstream in the lake. These intervals were selected to provide insight into the areal and volumetric extent of hypolimnetic water. Selected inflows and the outflow were sampled on the same frequency as lake stations. Sampling dates for 1975 are shown in Table 1-1 and sampling locations in Figure 1-1.

TABLE 1-1

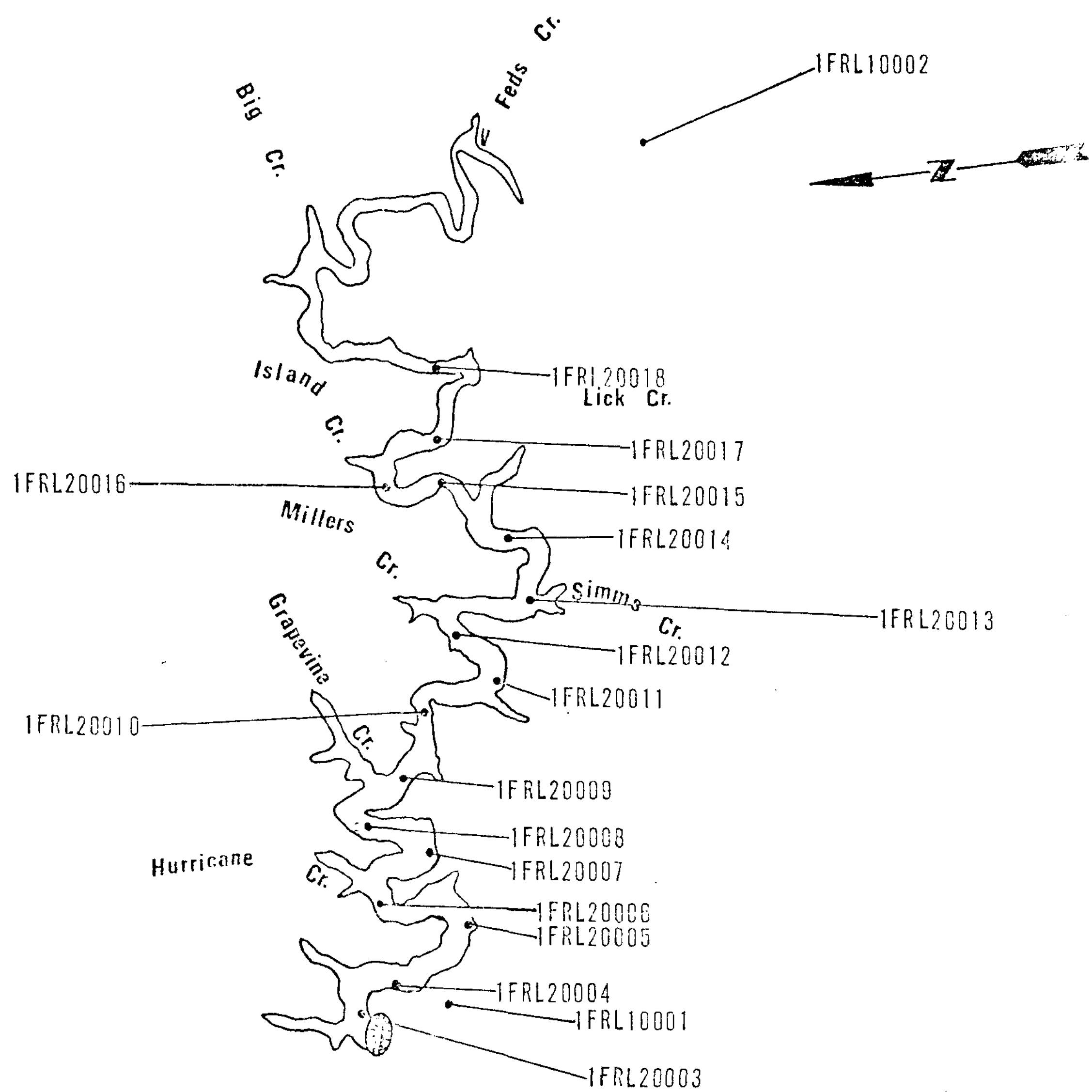
WATER QUALITY SAMPLING SCHEDULE FOR FISHTRAP PROJECT - 1975-1976

1975

J	F	M	A	M	J	J	A	S	O	N	D
		X		X	X	X	X				

1976

J	F	M	A	M	J	J	A	S	O	N	D
				X	X		X		X		



WATER QUALITY
SAMPLING STATIONS

LEVISA FORK
FISHTRAP LAKE
KENTUCKY
GENERAL LOCATION MAP
SCALE IN MILES
1 0 1 2 3

FIGURE 1-1

2.0 Contemporary Water Quality

2.1 Physical-Chemical Results

2.1.1 Temperature

Multi-level outlet structures permitted blending of waters from various depths in the lake near the dam. As a consequence of this blending ability, moderate success was achieved in meeting downstream temperature criteria established by agreement and a cooperative effort between the Corps of Engineers and the Commonwealth of Kentucky for a cold water fishery.

A large number of physical and chemical parameters, and moderate volumes of data, have been examined. For purposes of this document, only results pertinent to reservoir regulation or impact assessment will be presented.

Temperature profiles near the dam did not show significant thermocline formation in 1975 and 1976, slight temperature inflections were noted in summer months at several points in the water column. These inflections correlated with inflections or sharp changes in the distribution of dissolved oxygen and suspended materials (see Sections 2.1.2 and 2.2). Maximum vertical temperature change in the pool was 13.5 $^{\circ}C$ (29.2$^{\circ}C$ to 15.7$^{\circ}C$) between surface and the 65-foot levels, respectively, in July.

2.1.2 Dissolved Oxygen

The behavior of dissolved oxygen in Fishtrap is quite complicated, and apparently reflects effects of inflowing water and various mechanisms within the lake itself. Primary and secondary maxima in oxygen distribution occurred at times during summer months. At other times an oxycline formed, and values of effectively zero concentration existed below that point.

2.1.3 Metals

2.1.3.1 Iron

Concentrations of total iron at the main lake station in 1975-1976 ranged from 0.08 to 2.0 mg/l with a mean of 0.55 mg/l. Dissolved iron never exceed 0.10 mg/l

Discharge concentration for total iron ranged from 0.24 to 12.80 mg/l, with a mean of 1.66 mg/l. Total concentration reached 2.12 mg/l in 1974, however, dissolved iron concentrations were never higher than 0.10 mg/l.

Inflow concentration of total iron in Levisa Fork ranged from 0.71 to 32.25 mg/l with a mean of 3.90 mg/l. Soluble iron concentrations never above 0.10 mg/l.

This data seems to suggest that iron enters the pool in the suspended state and moves through or settles out without being converted to a soluble form.

2.1.3.2 Manganese

Total manganese concentrations at the main lake station varied from .02 to 0.97 mg/l with a mean of 0.12 mg/l. Dissolved manganese ranged from 0.02 to 0.83 mg/l with a mean of 0.08 mg/l.

Outflow levels of total maganese ranged from 0.04 to 0.76 mg/l with a mean of 0.26 mg/l. Dissolved manganese fluctuated from 0.02 to 0.68 mg/l with a mean of 0.16 mg/l.

Total manganese concentrations in Levisa Fork above seasonal-pool ranged from 0.01 to 1.20 mg/l. with a mean of 0.23 mg/l. Soluble manganese concentrations varied from 0.05 to 0.20 mg/l with a mean of 0.10 mg/l.

These data seem to suggest that manganese, for the most part, enters the project in the dissolved form and exist with little discernable change.

2.1.3.3 Mercury

Total mercury concentrations in the lake column ranged from 1.0 to 5 1 ug/l, with a mean of 2.5 ug/l. Soluble mercury ranged from 1.0 to 3.1 ug/l with a mean of 1.6 ug/l.

Outflow concentrations of total mercury ranged from 1.0 to 7.0 ug/l with a mean of 3.1 ug/l.

Total mercury concentrations in samples from Levisa Fork above the pool ranged from 1.0 to 8.0 ug/l with a mean of 4.0 ug/l. Soluble mercury values ranged from 1.2 to 3.5 ug/l, with a mean of 2.4 ug/l.

2.1.4 pH and Alkalinity

At the main lake station, values of pH in the water column ranged from 6.1 to 8.9 with a mean of 7.3 and alkalinity values ranged from 23 to 59 mg/l as $CaCO_3$ with a mean of 32 mg/l. Comparable values were measured in the outflow.

Values of pH in the inflow ranged from 7.0 to 8.1 with a mean of 7.5. Total alkalinity ranged from 31 to 86 mg/l as $CaCO_3$ in 1974 and from 17 to 86 mg/l as $CaCO_3$, with a mean of 58 mg/l. No trends relative to water quality of inflowing streams could be found.

2.1.5 Conductivity

Conductivity values in the water column of the pool at the primary lake station near the dam and ranged from 208 to 529 μmho/cm with a mean of 380 umho/cm.

Considerably higher conductivity values were found at the inflow although the range was variable and wide (50 to 850 umho/cm with a mean of 482 umho/cm). Future monitoring programs will include comprehensive conductivity studies at both inflow and lake stations.

Compared to Dewey and Grayson Projects, these values are relatively high and apparently reflect effects of ionic species introduced by surface disturbances and mining activities.

For purposes of the fishery and food chain within the lakes, it appears that phosphorus limits productivity.

Results of the type described above are typical for the predominately non-calcarious nature of this watershed. No deleterious shifts were noted for either alkalinity or pH.

2.2 Optical Properties of Water and Solids

Optical properties of water may be evaluated for such limnological purposes as study of stratification, turbidity, particle size distribution of suspended solids and plankton layer depths. Light transmissivity in water is one technique used to evaluate optical properties of this fluid. Measurements are made of effects of suspended materials on a beam of light traveling along a fixed pathway. Light transmission or attenuation varies in response to transparency of the water.

Instrumentation of the type described above was used to collect *in situ* data at Fishtrap Lake in 1975. Because of various performance and readout characteristics of the instrument, it is felt that data is of use only for ascertaining patterns of distribution of suspended material (qualitative evaluations) and not for evaluation of actual concentrations (quantitative evaluations).

In the summer months (June, July, and August), near the dam, apparent effects of density layering (increased levels of suspended materials) were noted at various depths. Variations in distribution of temperature and dissolved oxygen are noted at the same depths (See Sections 2.1.1 and 2.1.2 for further discussion).

Inspection of profiles taken at approximate one-mile intervals upstream from the dam added additional support to the density layering concept. Breaks or inflections in distribution of suspended materials, temperature and dissolved oxygen occur at the same depths. Although the picture is quite complicated, it appears that relatively low-temperature water with relatively high levels of suspended materials in the inflows moves into lower regions of the lake in a density underflow. Other effects are obviously superimposed upon the density layering phenomenon; for example, Secchi depths show a pattern of steadily increasing values from the inflows toward the dam. This indicates settling of suspended direction in the lake. This is expected because of the decreased velocity regime within the lake as opposed to the inflows.

2.3 Biological Results - incomplete

3.0 Results

Excessive sedimentation is the most significant problem affecting normalized operation and management of the Fishtrap Lake Project. Coal mining in the project watershed, both on and off Federal lands, is the primary source of the problem. Excessive sedimentation has resulted in both loss of lake storage and degradation of recreational usage and development potential.

Inflow of sediment from the watershed to Fishtrap Lake causes turbidity and sedimentation problems which overshadow effects of most other water quality problems.

4.0 Ongoing Sampling Program

Specifically, the ongoing sampling program will be oriented toward issues pertinent to existing or potential effects or sediment movement into and through the lake. Generally, the program is structured to describe, either separately or in combination, the various factors at the project which affect water quality. An interdisciplinary approach will be used to evaluate the physics, chemistry and biology of inflow streams, the lake and the outflows.

The basic study consists of four essential components: (1) *in situ* measurements to evaluate distribution of various properties in the lake, (2) chlorophyll/and total organic carbon measurements, (3) biological measuremets and (4) wet chemistry and various types for both immediate and long-term use, chlorophyll and total organic and chemical laboratory types of analyses for long-term use.

Properties of paramount importance for purposes of program include factors pertinent to water density, physical/chemical systems or maintenance of life and optical properties. Measurements of optical properties (light transmissivity or scattering) in water can be used for such purpose as evaluating stratification, plankton layer depth, "turbidity" estimation of particle size distribution, and estimation of suspended solids concentrations.

Benthic organism will be used, especially with respect to sedimentation effects, to monitor changing conditon in the watersheds of inflowing streams.

Chemical and physical parameters relevant to effects of sediment, such as metals and suspended solids, will be monitored on a routine basis.

1.0 Sampling Schedule

Physical-chemical samples were collected at Grayson Project at inflows, the lake, and outflows on a monthly basis during the periods on anticipated thermal stratification and at least once during the winter period. The benthic macroinvertebrate sampling schedule is shown in Section 2.2.1. In 1974, lake sampling was done at one station near the dam and in 1975 and 1976 at this station and others at selected intervals upstream in the lake. These intervals were selected to provide insight into the areal and volumetric extent of hypolimnetic water. Selected inflows and the outflows were sampled on the same frequency as lake stations. Sampling dates for 1974, 1975, and 1976 are shown in Table 1-1 and sampling locations in Figure 1-1.

TABLE 1-1

WATER QUALITY SAMPLING SCHEDULE FOR GRAYSON PROJECT

Year	J	F	M	A	M	J	J	A	S	O	N	D
1974				X	X		X	X	X	X	X	X
1975	X			X	X	X	X	X	X			
1976					X	X	X	X		X		

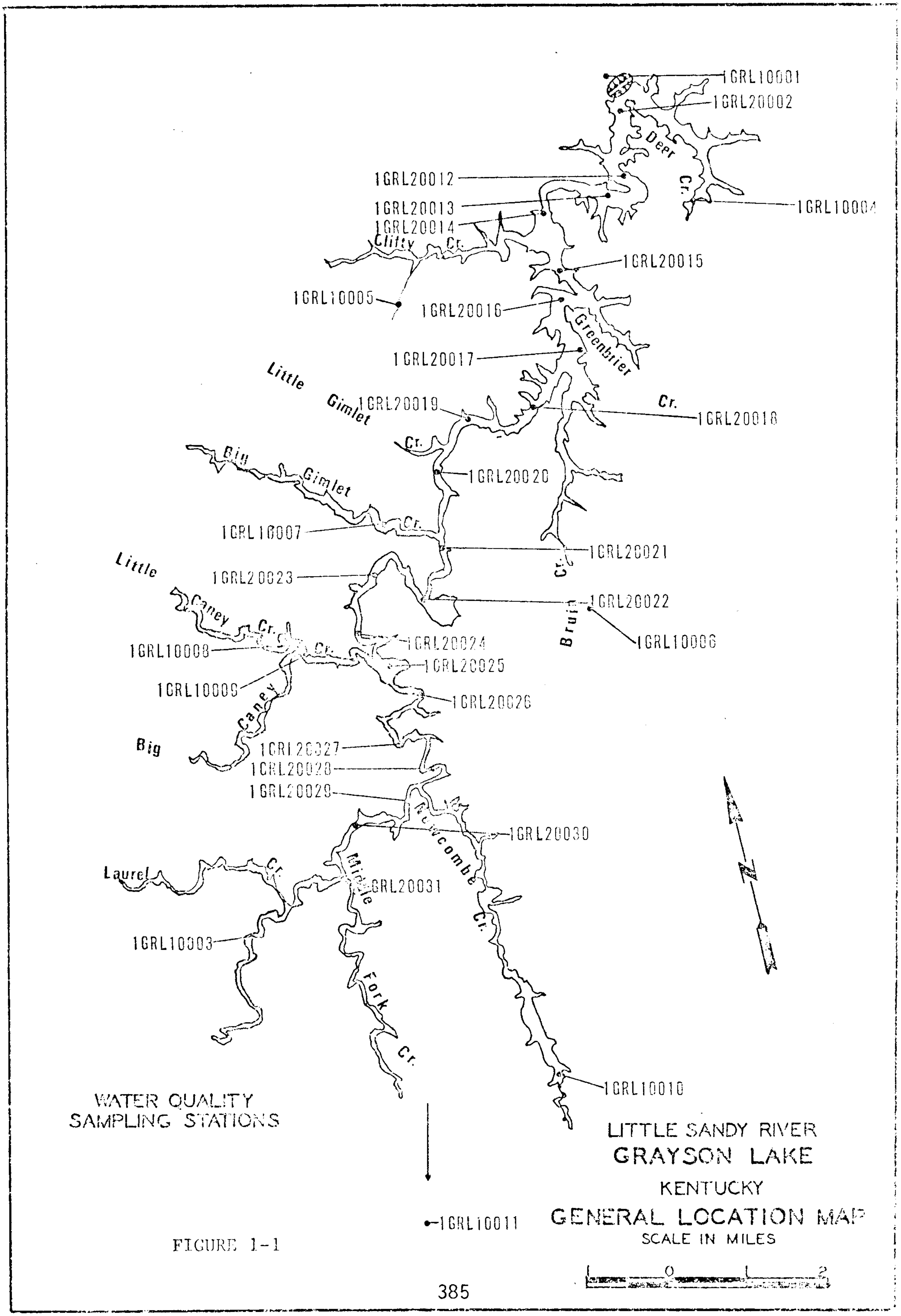

1GRL10001
1GRL20002
Deer Cr.
1GRL20012
1GRL20013
1GRL20014
1GRL10004
Clifty Cr.
1GRL20015
1GRL10005
1GRL20016
Greenbrier Cr.
1GRL20017
Little Gimlet Cr.
1GRL20019
1GRL20018
Big Gimlet Cr.
1GRL20020
1GRL10007
1GRL20021
Little Caney Cr.
1GRL20023
1GRL20022
Bruin Cr.
1GRL10006
1GRL20024
1GRL10008
1GRL20025
1GRL10009
Big Caney Cr.
1GRL20026
1GRL20027
1GRL20028
1GRL20029
1GRL20030
Newcombe Cr.
Laurel Cr.
Middle Fork Cr.
1GRL20031
1GRL10003
N
1GRL10010
WATER QUALITY
SAMPLING STATIONS
LITTLE SANDY RIVER
GRAYSON LAKE
KENTUCKY
GENERAL LOCATION MAP
SCALE IN MILES
0
1
2
1GRL10011

FIGURE 1-1

2.0 Contemporary Water Quality

2.1 Physical-Chemical Results

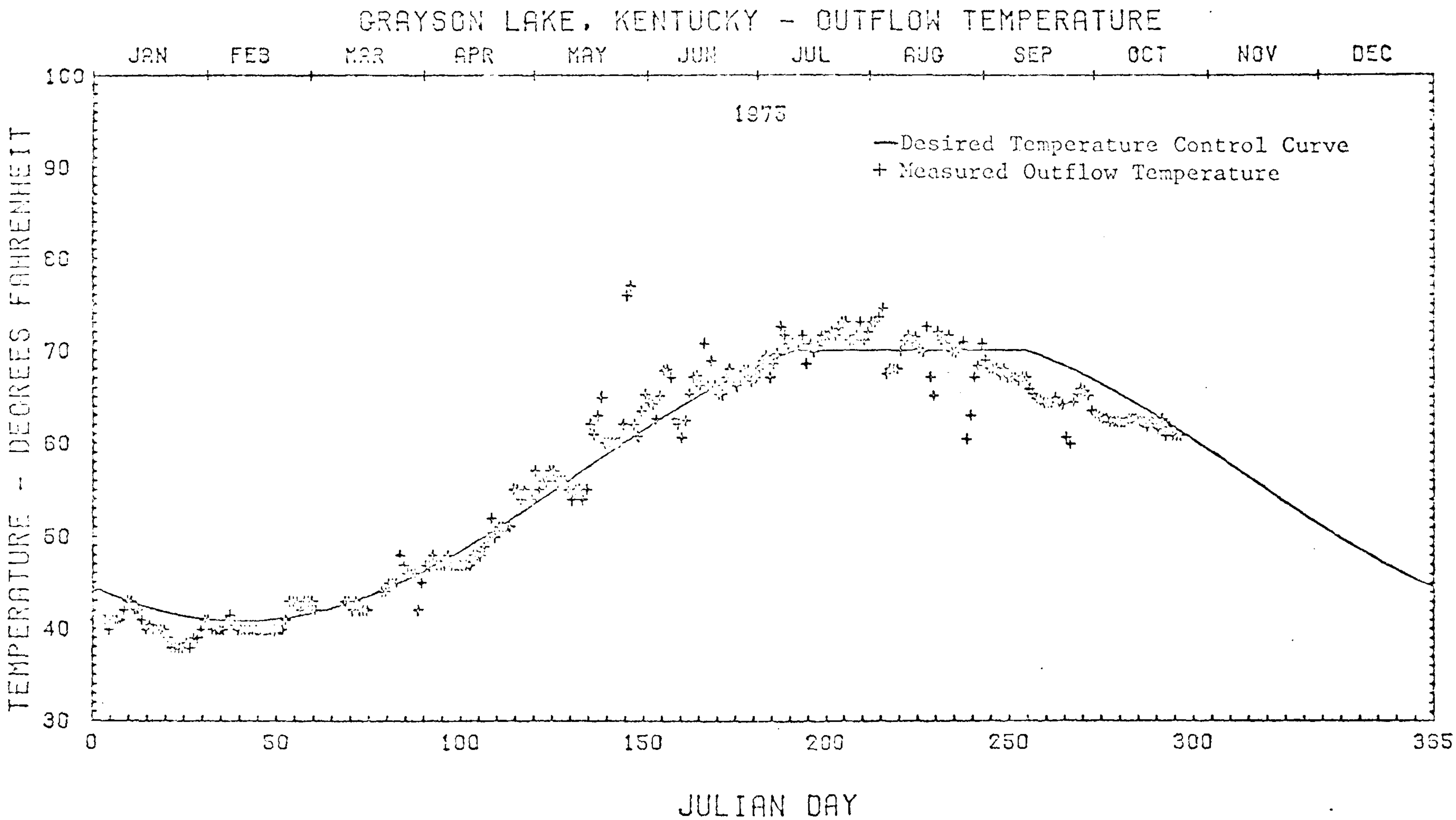
2.1.1 Temperature

Temperature profiles near the dam followed the "classic" pattern in Grayson Lake. A stable, sharp, thermal gradient developed during the summer and destratification occurred in early October. Nearly uniform vertical distributions of temperature occurred during winter months. Profiles taken in spring were indicative of transition states between isothermal and stratified conditions in the lake. The most drastic vertical changes in temperature occurred at levels 10 to 20 feet below the surface.

Multi-level outlet structures permitted blending of waters from various depths in the lake near the dam. As a consequence of this blending ability, moderate success was achieved in meeting downstream temperature criteria established by agreement and a cooperative effort between the Corps of Engineers and the Commonwealth of Kentucky for a cold water fishery. For example, temperature objectives and temperatures actually recorded for 1975 are presented in Figure 2-1. Constraints on temperature objectives are given below in Sections 2.1.3.1 and 2.1.3.2.

Temperature Control Curve and Measured
Outflow Temperatures at Outflow of
Grayson Lake.

FIGURE 2 -1



2.1.2 Dissolved Oxygen

Dissolved oxygen concentrations in the lake fluctuated from above saturation in the epilimnion to effectively zero in the hypolimnion during summer (stratification) periods. Positions of the oxycline were nearly identical with the thermal gradient. Oxygen destratification occurred at approximately the same time as the fall mixing. Outflow dissolved oxygen was consistently high due to high-level releases from within the reservoir and/or stilling basin reaeration of the discharged water. Values ranged from 7.0 (in August 1976) to 13.4 mg/l (12 December 1974).

2.1.3 Metals

2.1.3.1 Iron

Prior to thermal stratification in both 1974 and 1975, total and dissolved iron concentrations at the main lake station were relatively low. After thermocline formation, hypolimnetic concentrations reached 9.75 mg/l total iron and 7.05 mg/l dissolved iron in 1974, 13.25 mg/l and 7.17 mg/l total and dissolved iron respectively in 1975, and 4.15 mg/l total and 0.27 mg/l dissolved iron respectively in 1976.

As a result of the high concentrations of total iron in the hypolimnion, maximum discharge concentrations reached 2.45 mg/l in 1974, 4.45 mg/l in 1975, and 4.54 mg/l in 1976. Dissolved iron concentrations, however, were never higher than 0.20 mg/l, indicating that most dissolved iron quickly precipitated upon contact with the relatively high dissolved oxygen levels in the outlet works. This mechanism formed a reddish-orange coating on the substrate in the stilling basin and apparently inhibited production of benthos as documented in 1974 by sampling analyses conducted in the outflow area (see 2.2.1).

Inflow concentrations of total iron were highest in Newcombe Creek (31.97 mg/l), the Little Sandy River (7.25 mg/l), and Bruin Creek (5.09 mg/l). The maximum soluble iron concentration for all inflows for 1974-9175 was 0.15 mg/l in the Little Sandy River. These data seem to suggest that iron enters the pool in the suspended state and, after thermocline formation and deoyxgenation of the hypolimnion, is mobilized to the dissolved form prior to being precipitated in the outlet.

This mechanism of iron transport into and through the project poses a limitation on ability to provide low tailwater temperatures required to sustain the late summer trout fishery.

2.1.3.2 Manganese

During isothermal conditions, total and dissolved manganese concentrates in the water column at the main lake station were relatively low. During the periods that stratified conditions existed, epilimnetic concentrations of both forms of manganese were low, while hypolimnetic concentrations ranged from 2.5 to 5.0 mg/l. As expected, results of outflow samples confirmed that concentrations in bottom releases during the stratified periods exceeded desirable standards (range of 1.12 to 2.18 mg/l). This poses another substantial constraint on ability to meet low temperature tailwater objectives needed to support the downstream fishery during late summer.

2.1.3.3 Mercury

While values of total mercury as high as 12-15 ug/l have been measured from inflow, lake, and outflow samples, mean values from these locations range from 3.7 to 4.6 ug/l. Maximum filterable (dissolved) values ranged from 1.0 to 2.0 ug/l and mean values from 1.0 to 1.5 ug/l. These results are indicative that over half of the total mercury concentrations are associated with suspended materials in the water. The source and significance of these values are being investigated.

2.1.4 pH and Alkalinity

Values of pH in the water column at the main lake stations ranged from 5.9 to 8.9 and total alkalinity values ranged from 4.9 to 41 mg/l as $CaCO_3$. Such results are representative of a low buffering capacity and are typical for the predominantly non-calcareous nature of this watershed.

Values of pH in the inflow ranged from 6.0 to 8.0 and total alkalinity values ranged from 11 to 73 mg/l as $CaCO_3$. No trends relative to water quality of inflowing streams could be found. It is anticipated, however, that mining activities currently under way in the watershed might impact adversely on the regime of pH in both inflowing water and the lake. Accordingly, future monitoring programs will include comprehensive pH studies at both inflow and lake stations.

2.1.5 Conductivity

Conductivity values in the water column of the pool at the primary lake station near the dam were relatively low and ranged from 10 to 289 micro mho/cm.

2.1.6 Solids

Total suspended solids in the main lake station near the dam ranged from 5 to 86 mg/l in the water column. Outflow values ranged from 5 to 20 mg/l.

Although only limited solids data is available for most of the inflow stations, certain trends are indicated from inspection of the information.

Levels of total suspended solids in the inflows were variable among stations and exhibited a wide range. For 1974-1975, highest values recorded were at Little Sandy River (184 mg/l), Newcombe Creek (874 mg/l), and Bruin Creek (114 mg/l). The highest value recorded at Clifty Creek was 21 mg/l and at Deer Creek the minimum limit of sensitivity (5 mg/l) was never exceeded.

Two interesting observations emerged. First, the relatively high level of suspended solids at Newcombe Creek and the excessively high level at Bruin Creek correlate well with results of benthic analyses (see Section 2.2.1), which indicate degraded water quality for these streams. Second, the fraction of total volatile solids (10 and 99 mg/l) at Newcombe Creek is very high when compared to total suspended solids (18 and 114 mg/l). It is concluded, therefore, that a large proportion of the suspended solids is composed of volatile (combustible) substances such as coal. Corps personnel have, in fact, observed significant quantities of coal in the stream bed during periods of low flow.

2.2.0 Biological Results

2.2.1 Benthos

Benthic macroinvertebrates in a stream reflect both conditions at the time of sampling and the history of the quality of the aquatic environment for several months prior to their collection. These organisms are not highly mobile and are able to rapidly migrate from an area undergoing severe degradation. Consequently, certain species serve as indicators of degraded conditions resulting from moderate to severe pollution over extended periods of time, while others are indicators of a continuing high quality environment with excellent water quality.

The benthic macroinvertebrate sampling schedule at Grayson Project through April of 1975 is shown in Table 2-1. It was upon results of this sampling that conclusions in this document are based. Additional samples are available from various sites and from 1976 sampling, but have not been analyzed at this time. Refer to Figure 1-1 for location of sampling sites listed in the Table.

A synopsis of results of benthic macroinvertebrate analyses is presented in Table 2-2. Additional information and suggested causes of water quality are given in the following paragraphs.

Insufficient benthic data was available from the Little Sandy River inflow to determine any trends relative to time. Moderate diversity accompanied by a relatively high equitability indicates that the environment at this station is not favorable enough for a diverse benthic macroinvertebrate community to inhabit the area. This conclusion is further supported by the low density documented to exist at this station. Data suggest that size of gravel substrate is the factor limiting fauna present at this station.

While one benthic sample from the Middle Fork inflow does not provide enough baseline data to make any definite conclusions about the fauna at this station, certain trends seem to be indicated. Low density,

TABLE 2-1

BENTHIC MACROINVERTEBRATE SAMPLING SCHEDULE AT GRAYSON PROJECT

				1974							1975		
SAMPLING SITE	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR
Inflow													
Little Sandy River	X					X	X						
Middle Fork	X												
Newcombe Creek	X												
Bruin Creek		X											
Far Clifty Creek	X			X						X			X
Deer Creek	X												
Outflow	X			X			X						

moderate diversity, and very high equitability indicate slight degradation at this station. Even though an active strip mining operation utilizes the highway paralleling Left Fork, which is a tributary to Middle Fork, effects on the benthos were not greatly pronounced at our sampling station.

Benthos sampling at the Newcombe Creek station was not extensive enough to allow any projections of limiting parameters. However, because of the extremely low density, diversity, and equitability, it was apparent that the fauna at this station is severely limited by some water quality parameter or parameters, probably associated with inactive strip mining operations upstream of the sampling station.

Data from the Bruin Creek inflow station are indicative of a degraded environment. Again, mining activities are indicated as the cause.

Diversity and equitability values for benthos at Far Clifty Creek indicate good water quality. No limiting parameters are apparent. Even though this station is downstream of an active strip mine site, the fauna shows no indication of degradation. Inspections of the mining site by District personnel at the time of sampling indicated proper operational controls were being exercised by the mining firm involved. Results of the data obviously indicate that such controls can be effective in reducing environmental degradation.

TABLE 2-2

SYNOPSIS OF BENTHIC DATA USED AS LONG-TERM INDICATORS OF WATER QUALITY AT GRAYSON PROJECT[1]

Station	Insufficient No. Samples	Density[2]	Diversity[2]	Equitability[3]	Evaluation of Water Quality
Little Sandy River Inflow		Low	Moderate	Moderate	Fair
Middle Fork Inflow	**	Low	Moderate	High	Fair
Newcombe Creek Inflow		Low	Low	Low	Degraded
Bruin Creek Inflow		High	Moderate	Low	Degraded
Far Clifty Creek		Moderate	High	High	Good
Deer Creek	**	Low	High	High	Fair
Outflow		Low	Low	Low	Degraded

1 Further clarification of the results drawn from this table is presented in the test.

2 Evaluation of these parameters is arbitrarily established as low, moderate, or high.

3 Evaluation of water quality is arbitrarily established as degraded, fair, or good.

While more data will be necessary to form a complete picture at the Deer Creek station, initial results show the benthos at this station to be highly diverse although present in only moderate numbers. Dominance of intolerant forms, high diversity, and high equitability indicated good water quality with no apparent degradation.

The very low total number of benthic organisms recovered in the outflow, low diversity, and moderate equitability indicated a degraded environment. Of the total fauna present at this station, 75 percent were sessile organisms relying on plankton for nutrition. This data indicates that substantial concentration of plankters are contained in Grayson's discharge.

While plankton discharged from the project should provide a nutrient base for benthic macroinvertebrates (i.e., filter feeding tricopteran and dipterans), preliminary samples collected in the stilling basin suggests that no such development has occurred due to chemical characteristics of discharged water. (See Sections 2.1.3.1 and 2.1.3.2). At some point below the project where available oxygen has precipitated most heavy metals, this fauna should develop, offering an excellent food source for forage fish necessary for a self-sustaining downstream fishery.

3.0 Results

Temperature profiles near the dam followed the classic pattern in Grayson Lake. In 1974, a stable, sharp, thermal gradient was observed in summer months and destratification occurred in fall. Winter profiles showed a nearly uniform vertical distribution of temperature. Late winter and early spring results were indicative of transition states between isothermal and stratified conditions in the lake.

Dissolved oxygen concentrations in the lake fluctuated from above saturation in the epilimnion to effectively zero in the hypolimnion during summer (stratification) periods. Positions of the thermocline and oxycline were nearly identical. Oxygen destratification occurred at approximately the same time as fall mixing. Outflow dissolved oxygen was consistently high due to high-level releases from within the reservoir and stilling basin reaeration of the discharged water.

Multi-level outlet structures permitted blending of waters from various depths in the lake near the dam. As a consequence of this blending ability, moderate success was achieved in meeting downstream temperature criteria established by agreement and a cooperative effort between the Corps of Engineers and the Commonwealth of Kentucky for a cold water fishery.

However, concentrations of iron and manganese were high in hypolemnetic waters during periods of stratification and imposed constraints on meeting temperature objectives.

Levels of total mercury in excess of 5.0 ug/1 have been measured in both the inflow and outflow of the lake. The source and significance of these values are being investigated.

Relatively low values of alkalinity and the range of pH observed during the study period are representative of a low buffering capacity and are typical for the predominately non-calcareous nature of the watershed.

Conductivity values in the water column of the pool at the primary lake station near the dam were relatively low. Considerably higher conductivity values were found at certain of the inflows, although the range was variable and wide at these stations.

Total suspended solids in the main lake station near the dam and from the outflow were relatively low. Levels of total suspended solids in the inflows were variable among stations and exhibited a wide range. It appears that phosphorus limits productivity.

Results of biological sampling indicate that degraded environments exist at inflow stations on Newcombe and Bruin Creeks. These results are supported by conductivity and suspended solids data. Fair to good environments occurred at other inflow stations.

Biological results also indicate a degraded environment at the outflow during the periods of sampling and that substantial concentrations of plankters are contained in the discharged water. While plankton discharged from the project should provide a nutrient base for benthic macroinvertebrates, preliminary samples collected in the stilling basin suggests that no such development has occurred due to characteristics of discharged water. At some point below the project where available oxygen has precipitated most heavy metals, this fauna should develop, offering an excellent food source for forage fish necessary for a self-sustaining downstream fishery.

In summary, the overall water quality of Grayson project is arbitrarily rated fair to good. It is anticipated, however, that mining activities currently underway in the watershed might impact adversely on this regime of water quality both in inflowing water and the lake. Accordingly, future monitoring programs must include focused studies at both inflow and lake stations, and cooperative studies and regulatory effort with the Commonwealth of Kentucky and other appropriate agencies.

4.0 Ongoing Sampling Program

Specifically, the ongoing sampling program will be oriented toward issues pertinent to existing or potential effects of sediment movement into and through the lake. Generally, the program is structured to describe, either separately or in combinations, the various factors at the project which affect water quality. An interdisciplinary approach will be used to evaluate the physics, chemistry, and biology of inflow streams, the lake, and the outflows.

The basic study consists of four essential components: (1) in situ measurements to evaluate distribution of various properties in the lake, (2) chlorophyll and total organic carbon measurements, (3) biological measurements, and (4) wet chemistry and various types for both immediate and long-term use, chlorophyll and total organic and chemical laboratory types of analyses for long-term use.

Properties of paramount importance for purposes of the program include factors pertinent to water density, physical/chemical systems or maintenance of life, and optical properties. Measurements of optical properties (light transmissivity or scattering) in water can be used for such purpose as evaluating stratification, plankton layer depth, "turbidity" estimation of particle size distribution, and estimation of suspended solids concentrations.

Benthic organism will be used, especially with respect to sedimentation effects, to monitor changing condition in the watersheds of inflowing streams.

Chemical and physical parameters relevant to effects of sediment, such as metals and suspended solids, will be monitored on a routine basis.